

Proceedings of the Twentieth Indian Science Congress

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General.

The twentieth meeting of the Indian Science Congress was held at Patna from January 2nd to 7th, 1933.

The inaugural meeting was held on Monday, January 2nd, 1933, at 6-30 P.M. in the Wheeler Senate House, Patna. Sir Saiyid Sultan Ahmad, Kt., Barrister-at-Law, Chairman of the Local Reception Committee, welcomed the delegates in a short speech and requested the Hon'ble Sir Courtney Terrell, Kt., Chief Justice of the Patna High Court, to open the Congress. The President of the Congress, Dr. L. L. Fermor, O.B.E., D.Sc., then delivered his address.

The Sectional Presidential Addresses were delivered as follows :—

TUESDAY, *January 3rd*, 10 A.M., Medical and Veterinary Research ; 11 A.M., Mathematics and Physics ; 12 NOON, Botany.

WEDNESDAY, *January 4th*, 10 A.M., Agriculture ; 11 A.M., Chemistry ; 12 NOON, Zoology.

THURSDAY, *January 5th*, 10 A.M., Geology ; 11 A.M., Anthropology ; 12 NOON, Psychology.

The following functions were arranged in connection with the Congress :—

TUESDAY, *January 3rd*, 2-30 P.M., visits to :—

1. Oriental Khuda Bux Library.
2. Patna Museum and Sinha Library.

WEDNESDAY, *January 4th*, 2-30 P.M., visits to :—

1. Veterinary College, Patna.
2. Golghar, Patna.

4 P.M., Sir Saiyid Sultan Ahmad, Kt., ' At Home '.

THURSDAY, *January 5th*, 2 P.M., visits to :—

Bihar-College of Engineering, Patna.

4 P.M., Garden Party by Rai Bahadur Radha Krishna Jalan, Patna City. Leave by steamer from Mahendru Ghat at 3 P.M.

FRIDAY, *January 6th*, Whole-day excursion to Imperial Institute of Agricultural Research, Pusa.

4-30 P.M., The Registrar, Patna University, ' At Home '.

SATURDAY, *January 7th*, Whole-day excursion to Nalanda Excavations.

The Joint-Meetings of the Sections were held as follows :—

WEDNESDAY, 4th January, at 2-30 P.M. Sections of Botany and Zoology on 'The necessity of Marine Biology Station in India'.

THURSDAY, 5th January, at 10 A.M. Sections of Agriculture, Chemistry and Botany on 'Virus diseases of Plants'.

The popular lectures were delivered as follows :—

January 3rd, 6-30 P.M., 'Some problems of Forest Mycology and Pathology', by Dr. Krishnadas Bagchee, D.Sc.

January 4th, 6-30 P.M., 'Movements of the Continents which have produced the present features of the Earth's surface', by W. D. West, Esq., M.A.

January 5th, 6-30 P.M., 'Electrical Measurements', by Prof. A. T. Mukerji, I.E.S.

January 6th, 6-30 P.M., 'Mohenjo-Daro and the Indus civilization', by K. N. Dixit, Esq., M.A.

The Council of the Indian Science Congress met on the 2nd January, 1933, at 12 NOON.

The Sectional Committees met on the 2nd January, at 3-30 P.M.

The Executive Committee met on the 4th January, at 2 P.M.

The General Committee met on the 5th January, at 2 P.M.

Opening Proceedings.

The twentieth session of the Indian Science Congress was opened on Monday, January 2nd, 1933, at 6-30 P.M. by the Hon'ble Sir Courtney Terrell, Kt., Chief Justice of the Patna High Court, and Vice-Patron of the Congress, at the Wheeler Senate House of the Patna University, in the presence of a large gathering of delegates and visitors.

In opening the Congress Sir Courtney Terrell, Kt., spoke as follows :—

“ GENTLEMEN,

It is an ironical fact that the twentieth Indian Science Congress is greeted by a representative of a reactionary and obscurantist class. You are probably astonished that this province should have deputed a lawyer to voice its welcome to Indian Scientists but I must plead in explanation that in Bihar and Orissa the law is esteemed and remunerated beyond all other professions, and in this opinion our people perhaps fondly imagined that they were honouring you in their selection of the head of the Judiciary for this pleasant duty.

We rejoice that you have chosen Patna for your deliberations. We cannot offer you the amenities which you would have found in great cities but we claim to be more representative of the real India and we furnish a wider field for scientific research than any other province. From Nepal to the Sea, from the Santal Parganas to Palamau, from Champaran to Balasore, from Purnea to Kalahandi you will find more variety in social conditions, races and languages, in climatic, geological and biological features than can be presented by any other province in India. We are a great agricultural people and yet have the most abundant mineral resources for future industrial wealth; sugar and lac are ours and thriving fisheries, and with all these advantages we suffer maladies of a peculiar intensity and variety. In fact Anthropology, Engineering, Geology, Chemistry both organic and inorganic, Botany, Zoology, and Medicine offer an enormous field for investigation.

In this province moreover I make bold to say we have more people of common sense, wisdom and goodfellowship than you will find in any other population of forty million souls. The waves of stupid discord which disturb the emotional atmosphere of other parts of India affect us but little. There is a cheerful spirit of co-operation and quiet striving for the common welfare not often seen else-

where and I for one would rather be here than in any other part of the Continent. Whether one's lot be cast in Law, Science, Administration, Cultivation or Manufacture one can find excellent comrades in spite of differences in caste and religion. Therefore you will find this a good place for your meetings and we on our part expect much benefit from your sojourn with us.

The abstract of papers for your consideration is of imposing size and serves to illustrate the vast expanding universe of knowledge. You who live ever on the periphery of a mighty development where the field for any single man is a rapidly diminishing fraction of the outer area must feel the ever increasing difficulty of integrating that area for human comprehension. The task of the scientific philosopher grows ever greater with the radial acceleration of knowledge from the centre of ignorance. Yet periodical attempts at such integration are necessary if the direction of expansion is to remain under human control to serve human welfare. We do not observe or anticipate any great modification of the human body. Everything has to be translated into terms of our very limited senses before it can be appreciated by the mind, and however we refine our conceptions they must remain anthropomorphic in quality and quantity. The mathematician has perhaps the easiest task in those fields which are susceptible to his methods, for his symbols though anthropomorphic in origin and essence have apparently unlimited capacity. But how is one to integrate the advances in knowledge of organic life? One trembles to contemplate the compilation of the bio-chemical or entomological treatise fifty years hence, for the man of fifty years hence will not differ materially from the man of to-day. There is yet a further difficulty,—at any moment an occurrence at any point on the ever expanding surface of collective knowledge may affect the whole development and compel a new orientation of effort. The difficulty of inter-communication between groups of scientists shews a geometrical increase and the establishment of nodal points of exchange is becoming a superhuman task. The scientific world is now seeking some system of discipline over groups and sub-groups of investigators and the establishment, all over the world, of various councils for scientific research now affords some guidance for future workers. A sacrifice in the matter of independence of inquiry is compensated by better co-ordination for the benefit of all. We need general officers to control inquiry quite as much as regimental soldiers in the front line and behind these again corps commanders to deal with wide questions of strategy having regard to human needs. And in science we need have no fear that

we shall lose the free-lance soldier of fortune. He will always be a glorious figure and always with us in our invasion of the secrets of nature. To pursue this military analogy one stage further, might not each sub-section of this congress appoint a staff officer to prepare an appreciation of the local situation and suggest plans of campaign for the following year ?

Gentlemen, I envy you in your work. While you pursue your shining path I must return to the Courts to deal with the folly, greed, crimes and quarrels of my fellow subjects. Your quest is not obscured by codes and rules of evidence. Had I the time, and you the interest, I might amuse and possibly shock you with tales of the legal laboratory and the conditions under which my investigations have to be conducted. We do our best under those conditions and it is surprising that we do no worse. Perhaps some day even judicial trials may proceed on rational lines and we may be enabled to arrive at Truth rather than 'victory-according-to-the-rules-of-the-game',—but not in my time alas !

There has been compiled for your use a compendious hand-book describing matters of scientific interest in our province and I am sure you will find it informative and useful. From it you may learn that Patna is something more than 'the place the rice comes from' and that Bihar and Orissa is something more than a junior province avoided by cold weather tourists.

On behalf of Bihar and Orissa then I bid you welcome, and wish you a happy visit. We shall follow your deliberations with the greatest attention and we hope that you may be sufficiently interested soon to meet again in this the best of Provinces."

After the opening of the Congress the President, Dr. L. L. Fermor, D.Sc., delivered his Presidential Address.

At the conclusion of the address Prof. S. P. Agharkar moved a vote of thanks to the Hon'ble Chief Justice for having consented to open the Congress, which was carried by acclamation.

Presidential Address.

Congress President :—DR. L. L. FERMOR, O.B.E., D.Sc.,
A.R.S.M., F.G.S., M.Inst.M.M., F.A.S.B.

THE PLACE OF GEOLOGY IN THE LIFE OF A NATION.

I.—General.

To accept an invitation to preside over the Indian Science Congress is to accept a great honour, and I thank you gratefully, fellow-scientists, for this. But it is also to undertake a great responsibility, not the least portion of which is to deliver a Presidential Address at the commencement of the Session.

Before dealing with the special subject of my address, it seems desirable that I should first notice a few events and matters of interest or importance to scientists in India, including a reference to three of your Past-Presidents.

The first is Dr. Martin O. Forster, your President at the 12th Congress held in Benares in 1925. He is due to retire shortly from the responsible position of Director of the Indian Institute of Science at Bangalore, a post that he has held for over 10 years. As scientists, we thank him for the fruitful work he has done at Bangalore in supervising and stimulating the development of research ; and as friends we wish him happiness and a further spell of usefulness on his return to England.

Dr. Forster is to be succeeded by Sir C. V. Raman, your President at the 16th Congress held at Madras in 1929. The high quality of Sir Chandrasekhara's work at the Indian Association for the Cultivation of Science in Calcutta and as Palit Professor of Physics at the University of Calcutta, and his inspiring leadership in the development of a school of workers in Physics, is a happy augury to the application at Bangalore of a further stimulus to scientific research at that southern centre. Calcutta's loss will be Bangalore's gain. At present Calcutta may be regarded as the centre of scientific research in India ; but, with the transference to Bangalore of one of her leading investigators, she will have to guard her laurels.

The third Past-President I wish to mention is Lt.-Col. R. B. Seymour Sewell, who is leaving India in April on leave preparatory to retirement from his post as Director of the Zoological Survey of India. We are not, however, at once to lose his services completely, for he has been appointed to lead the Sir John Murray Oceanographic Expedition to the Arabian Sea. Many of you are familiar with the results of the famous research expedition of H.M.S. *Challenger*, which, during the

years 1873-76, explored the oceans of the world. The results of these researches are embodied in a monumental set of volumes issued over a period of nearly two decades under the editorship, first of Sir C. Wyville Thomson and later of Sir John Murray. The survey of the oceans was not, however, complete, the study of the Arabian Sea being omitted. Sir John Murray in his will left a sum of money for this survey, and now that it has been decided by his trustees to complete the task, they may be regarded as very fortunate in having been able to secure the services of Col. Sewell, with his wide experience of oceanographic research obtained as Surgeon-Naturalist to R.I.M. *Investigator*. We wish Col. Sewell every success in this new field of activity.

To one other scientist I must refer, namely Sir Ronald Ross, who died at the age of 75 during the past year. You are all aware of his discovery of the method by which the parasite of malaria enters the human body, and of the enormous development in tropical medicine that has followed upon that epoch-making discovery. Ross' work was done in India and it has led to untold benefits to millions of inhabitants both of India and of other tropical countries. Sir Ronald left India before the foundation of our Congress, so that we have not had the privilege of his presiding over one of our gatherings. Nevertheless, we shall honour ourselves by recording our great loss in the death of one of the most distinguished scientists who has ever worked in India.

An event of major importance to the development of science in India during the past year was the decision made by a group of scientists during the last session of the Indian Science Congress at Bangalore to publish a scientific journal on the lines of the well-known English weekly journal, *Nature*. A committee was appointed and eventually the publication has been commenced of a monthly journal entitled *Current Science*; the first issue appeared in July, 1932. You will all agree that the journal is a success, for there has been no lack of material suitable for publication and the journal is pleasantly printed on good paper. On one point, however, the Board of Editors have cause for anxiety. The University of Madras and the Indian Institute of Science have made grants towards the maintenance of this journal, and, in addition, there are receipts from the sale of the journal and from advertisements. The total receipts from these sources is not, however, sufficient to meet the total expenditure, and for its continuance the journal will require either additional grants from other bodies, or an increased number of subscribers. These are hard times and it is going to be difficult to secure donations from university bodies. But when I mention that the present year's budget of the journal has been framed on the basis of only 300 subscribers, which is less than one per million inhabitants of the

country, and that 200 additional subscribers would square the budget, it will be seen that if Indian Science deserves the dignity of supporting an All-India journal in science, it can easily secure this dignity by what is really a trivial increase in the number of subscribers; for what are 500 subscribers amongst over 300 million people. No doubt, many of you have been waiting to see what the journal was like before subscribing. Now that you see the result, I hope that as many as possible will send in their subscriptions.

It has been suggested that as the Indian Science Congress may be regarded as the parent of this journal, the Congress should make a substantial annual grant to *Current Science*. This suggestion will no doubt be considered fully by the Council of the Congress; but we must remember that our Congress is not financially a profitable organisation, and is itself dependent at each session upon generous donations from universities and other bodies and from the Local Government concerned, in augmentation of the subscriptions of the members of the Congress.

As this is the 20th Session of our Congress, introducing the 20th year of our existence, a few remarks on our progress may be appropriate. The history of the foundation and growth of the Indian Science Congress was given by Dr. J. L. Simonsen in his Presidential Address to the 15th Congress. This history can be accepted as authoritative, as Dr. Simonsen was, as you know, one of the Joint Founders of the Congress. From his address you will discover that the initial meeting that led to our formation was held in 1912 in the rooms of the Asiatic Society of Bengal, and that it was resolved that the Asiatic Society of Bengal be asked to undertake the management of a Science Congress to be held annually. The first Congress was held in Calcutta in 1914 under the ægis of the Asiatic Society of Bengal, and we have since been indebted annually to this Society for our resuscitation at each meeting. We have our own two General Secretaries upon whom much work falls, but two of the officials of the Asiatic Society of Bengal, namely the General Secretary and the Treasurer, have all the time done very heavy work for the Congress, particularly in the publication of reports of our meetings and in keeping our accounts.

I use the word 'resuscitation' because until 1931 our Congress had no permanent organisation. In 1931, however, a constitution was adopted whereby we became a continuous organisation under the title of the 'Indian Science Congress Association' with a roll of permanent members, of whom at present we have about 225. In addition we recruit annually Sessional Members, Associate Members, and Student Members. The administrative work of the Indian Science Congress Association is conducted by an Executive Committee of 11 members, including the President, the retiring President, and two General

Secretaries, the Treasurer (who is the Treasurer of the Asiatic Society of Bengal for the time being), and the General Secretary of the Asiatic Society of Bengal, who is really the Manager of the Congress and Editor of our Proceedings. In this way the historical connection between the Indian Science Congress and the Asiatic Society of Bengal has been put upon a permanent footing. This means also that the office of the Congress is in the rooms of the Asiatic Society of Bengal and that we receive the services of the General Secretary and Treasurer of that body free of charge. I have mentioned all this to indicate the extent to which the Indian Science Congress is a dependent body financially, and not yet in a position to provide donations towards laudable scientific enterprises such as *Current Science*, or towards endowing particular researches in the manner undertaken by the British Association for the Advancement of Science in England. *Current Science* will no doubt eventually pay its way; but we could well do with funds for financing special items of research by private workers. We may hope perhaps that eventually donations for this purpose will be forthcoming from generous donors, who may perhaps remember the Indian Science Congress in their wills.

I have referred above to our *Proceedings*. As you know, the Proceedings of each meeting are now published annually by the Asiatic Society of Bengal as a special volume. This special publication dates, however, only from the 9th meeting. The reports of the first 8 meetings were published as special parts in the *Proceedings of the Asiatic Society of Bengal*. This Society has now very generously undertaken to reprint, at its own expense, the Proceedings of the first 8 meetings in a form homogeneous with the later reports. The Proceedings of the 1st, 2nd, 4th, and 5th meetings have been issued and those of the 3rd are in the press. For financial reasons, the Society has found it necessary for the present to postpone the reprinting of the Proceedings of the 6th, 7th, and 8th Congresses, but we may expect these eventually. In view of what I have said above it is evident that we have been very much beholden for a long period of years to the generosity and assistance of the Asiatic Society of Bengal, and I wish at this place to mention specially the name of Mr. Johan van Manen, the General Secretary of the Asiatic Society of Bengal, who has, for many years, acted as Editor of our Proceedings as well as helping in many other ways. It is also suitable that I should mention specially Prof. S. P. Agharkar, who has been one of our two General Secretaries since 1924, carrying on his duties in turn with Dr. Simonsen, Dr. Norris, and Dr. Dunnicliff, and now with Mr. West, whom we welcome on the Executive Council of the Congress.

I have mentioned that this is our 20th year of existence. What is the object of our existence? According to our rules,

the object of the Indian Science Congress is the 'advancement of Science in India by the annual holding of a Congress'. The advancement of science may be effected in two ways. That which occurs first to our minds is undoubtedly the prosecution of research for the purpose of discovering new facts of Nature and, if possible, of explaining the meaning of these facts. But the advance of science can also be helped by arousing the interest therein of the general public; for not only does our work conduce in many cases to the welfare of mankind, but it also requires the support of mankind in the provision of facilities and specially in the provision of finance. For both reasons, therefore, our Congress is in its annual activities a peripatetic body, meeting in turn in the principal cities of India so that each may become aware of our activities and our needs. This aspect of the scope of our activities may be summarised by the statement that in the first 20 years of our existence, we have met three times each in Calcutta, Madras, and Bangalore, twice each in Lucknow, Lahore, Bombay, and Nagpur, and once each in Benares and Allahabad, whilst we are now meeting for the first time in Patna. It is desirable also that we should cater for as many branches of science as possible, not only by the creation of separate sections, of which we now have 9, which collect each the devotees of their own science, but also in the Congress as a whole as represented by the President and his Presidential Address. It may interest you, therefore, to know that the first 20 Presidents have been distributed as follows:—Medicine, Geology, and Chemistry, three each; Botany and Zoology, two each; and Geography, Meteorology, Agriculture, Physics, Mathematics, Business, and Engineering, one each. For the next—the 21st Congress—a Physicist has been selected.

The catholicity of our activities, both in place of meeting and choice of President, is illustrated by the foregoing figures. The extent to which this catholic behaviour and outlook has been successful is perhaps well illustrated by the astounding growth in the activities of our Congress. At the first meeting the number of members was 79, one Presidential Address was given, 35 papers were read, and the published Proceedings occupied 8 pages of print. Ten years later, at the 11th meeting, the number of Full and Associate Members was 403, with 290 Student Members. One general Presidential Address and 8 Sectional Presidential Addresses were given, 264 papers were presented, and the published Proceedings occupied 264 pages of print. At the 19th meeting, the number of Full and Associate Members was 690 and of Student Members 183. There were 10 Presidential Addresses, general and sectional, and 693 papers occupying 467 pages of Proceedings. This growth in the attendance at our meetings shows increasing interest; but it is a question whether this vast increase in the number

of papers presented can be desirable, for in the time available it is impossible to read more than a fraction of the papers offered. Thus at the 19th Congress 221 papers were presented to the Chemical Section; it seems unlikely that even a quarter of these can have been profitably read and discussed. Of course, this flood of papers reflects to some extent the activity of research in India in the branches of science concerned, but one wonders if there is not some room for selection by the Sectional Committees of those papers that are most suitable for presentation at the Sectional meetings, taking into account the general interest and importance of each paper.

This growth in the activities of our Congress has been accompanied not only by a growth in volume but also in the number of recognised sections. The original 6 sections were Chemistry, Physics, Geology, Zoology, Botany, and Ethnography. Agriculture was added at the 2nd Congress. The Physics section became the section of Physics and Mathematics at the 4th Congress, when Ethnography was also amalgamated with Zoology. At the 6th Congress the sections were increased to 7 by the addition of a section of Medical Research. At the 8th Congress, Ethnography was separated from Zoology again and made into a separate 8th section of Anthropology and Ethnography, to become a section of Anthropology at the 9th Congress. At the 12th Congress a 9th section of Psychology was added, and these are our 9 sections now.

During the vast growth in the number of papers read at several of the sections, Geology has remained a small section, and the largest number of papers that has been presented at one meeting is 36. The relatively small number of papers offered in this science is partly due no doubt to the fact that the meetings are held at a time when the officers of the Geological Survey of India are absent on field duties, and to geologists as a whole not caring to offer papers if they cannot be present to read them. Some other sections, e.g. Anthropology and Psychology, also are happy in that a manageable number of papers is presented, and I commend the example of these smaller sections to the notice of some of their bigger brethren.

II.—The Place of Geology in the Life of a Nation.

This brings us to the end of my remarks upon matters connected with the progress and welfare of our Congress. I now propose to discuss, in as general a manner as possible, a subject of more specialised interest, namely the Place of Geology in the Life of a Nation.

Those of you who have pondered upon the relationship between cause and effect must realise that anything that happens now to any person or thing may be regarded as the latest unit in a continuous chain of cause and effect. And you will pro-

bably permit me to summarise epigrammatically the results of your thoughts by likening life to an algebraical equation.

As you know, an important feature of such an equation is that the sum of the items on the right side must equal the sum of the items on the left side. Life is rather like this. A present happening may be regarded as the right side of an algebraical equation, and all the events that have led up to this happening may be regarded as constituting the left side of the equation.

To take an example, the fact that I am addressing you this evening, here, depends upon the facts, among many others, that I was born on a certain date, that I took up the study of science, that I was diverted to geology from metallurgy, the profession I originally selected, that I secured an appointment in India, that I have remained in service until this date, that your Council chose this place and date for our meeting and selected me to preside, and that I have succeeded in reaching this room without being involved in any accident. If any one of the facts mentioned had been different, I should probably not be here this evening.

An equation of this type, that is to say one involving cause and effect, differs in one essential particular from the algebraical equations of our class rooms. The equations of our school algebra are static equations, whereas those of the type we are now discussing are kinetic ones. For on each side of the equations of life there is an energy factor implying movement in the past and the possibility of movement in the future.

It is this energy factor that conditions Evolution, which, using our simile, may be described as the grand and impressive kinetic algebraical equation of the universe, on the left side of which is included not only the magnificent succession of events constituting the evolution of the stellar universe, but also the section of these events that has led to the evolution of the solar system and the birth of our planet; in addition it includes the much smaller, though to us vitally important, series of events that has led to the evolution of life upon our planet including the evolution of Man, followed by the still smaller series of events that constitutes the progress of human history down to its present point. The major portion of this grand series of events is the field of study of the Astronomer. With the formation of the earth, the field of study of the Geologist was provided. The evolution of life falls also within the realm of the geologist; but the latest section of this series of events, affecting human beings, falls within the sphere of studies of the Historian. The study of the present results of this evolutionary series of changes falls within the realms of geography, meteorology, botany, zoology, and anthropology, to mention sciences that in their historical or fossil aspect are comprised under geology.

You will now ask Then what is geology and the true field of study of the geologist? I cannot do better than quote the two opening paragraphs of Sir Archibald Geikie's 'Text-book of Geology':—

'Geology is the science which investigates the history of the Earth. Its object is to trace the progress of our planet from the earliest beginnings of its separate existence, through its various stages of growth, down to the present condition of things. Unravelling the complicated processes by which each continent and country has been built up, it traces out the origin of their materials and the successive stages by which these materials have been brought into their present form and position. It thus unfolds a vast series of geographical revolutions that have affected both land and sea all over the face of the globe.

Nor does this science confine itself merely to changes in the inorganic world. Geology shows that the present races of plants and animals are the descendants of other and very different races that once peopled the earth. It teaches that there has been a progress of the inhabitants, as well as one of the globe on which they have dwelt; that each successive period in the earth's history, since the introduction of living things, has been marked by characteristic types of the animal and vegetable kingdoms; and that, how imperfectly soever they may have been preserved or may be deciphered, materials exist for a history of life upon the planet. The geographical distribution of existing faunas and floras is often made clear and intelligible by geological evidence; and in a similar way, light is thrown upon some of the remoter phases in the history of man himself.'

From this you will gather that geography is the branch of geology that describes the particular shape and form of the earth's surface at the moment. With the continuance of the operation of geological processes, geography changes slowly through the ages, and looking backwards and making use of geological observations, we find that at previous periods in the earth's history the distribution of land and water, of mountain and valley, has often been vastly different from the present.

The geography of the earth at any moment, including its climate, flora and fauna, and the inherent possibilities of further change, is, in fact, the right side of that kinetic algebraical equation, of which the left side is the geological history of the earth down to that moment. In fact, in mathematical parlance, the geography of the earth is a function of its geological history.

Those of you who have studied history, by which I now refer to human history, must have noticed the extent to which

this history is related to geography: how coasts, seas, rivers, mountains, and climates, have exercised an important influence over the migration of races, and their struggles—one race with another, and upon the distribution of tribal and national boundaries. It is probable, nevertheless, that the majority of you have not realised that the guiding factors underlying geography were geological ones, and that, in fact, the events that constitute geological history have exerted a profound and far-reaching influence upon the history of mankind, both in general and in detail.

On the wall here is a geological map of the world.¹ The colours indicate the distribution of geological formations of different ages and origin. As you know, the land of the world occupies about a quarter of the surface, the oceans occupying the remaining three-quarters. According to some geologists, the land area was once vastly greater, and according to most, the proportion of land and sea has varied greatly throughout the ages. One major deduction based on widespread geological evidence is that South America, South Africa, Australia, India, and Antarctica, were once all part of a continuous continent known as Gondwanaland. Views differ as to the method by which this continent was dismembered. According to one hypothesis, known as the hypothesis of continental drift,² the existing continents were grouped in Carboniferous times as one continuous land-mass, with all the existing parts of Gondwanaland in apposition to southern Africa. Subsequently, on this view, the continuous land-mass was fractured, with drifting apart of the fragments to form the present continents. On this view, the continuous attached to Africa near Madagascar, and gradually floated or drifted north-eastwards.

The second and older hypothesis, whilst accepting the fact of Gondwanaland, supposes that it was formerly a much larger continent than can be deduced by simply fitting the existing fragments together, that Africa and India were then at approximately their present distance apart, and that the separation of these two countries was effected by the foundering or sinking of the intervening portions of the continent. Some geologists find it difficult to visualise the machinery of foundering, and consequently support *in toto* the hypothesis of continental drift. Foundering can be explained, however, either by the compression of rocks underlying the sunken parts of the

¹ F. Beyschlag, 'Geologische Karte der Erde', 1929-1932.

² Osmond Fisher: 'Physics of the Earth's Crust', pp. 339, 380, (1889).

W. H. Pickering, *Journ. Geol.*, XV, pp. 23-38, (1907).

F. B. Taylor, *Bull. Geol. Soc. Amer.*, Vol. 21, pp. 179-226, (1910).

A. Wegener, 'Die Entstehung der Kontinente und Ozeane', (1922): English translation (1924).

continent into a denser phase, e.g. gabbro into eclogite,¹ or by the lateral underground squeezing of magma from below the foundering portions. Whichever of these hypotheses relating to the break up of Gondwanaland be true, the cause has to be found. I do not propose to discuss this here, but only to point to the fact that the existing fragments of Gondwanaland are now separate, and that India has sea-coasts that she would not have had but for this disruption. Mr. West proposes to discuss the hypothesis of continental drift in one of our evening lectures, so that I need not refer further to this question. As a side-issue I may mention, however, that the expedition that Col. Sewell is to lead to the Arabian Sea may obtain, if rock specimens in any quantity can be secured from the bottom of the ocean, evidence helpful to the determination of whether India has been separated from Africa by the foundering of the intervening land, or by drifting apart.

I will now invite your attention to these two maps of India, one geological and the other orographical. India is a large country, whilst the number of geologists who have been at work therein is small; in consequence, there are still great gaps in our knowledge, and our geological map is a very imperfect production. Sufficient, however, has been ascertained to reveal the general outline of the geology of India and to render possible a comparison between the geology and the orographical features as represented in these two maps. From this comparison you see at once that there must be some close relationship between the geology of India, that is to say its geological history, and the present topographical features. From these maps you will see also that the Indian Empire, as at present constituted, is one of the most natural geological and physical units on the surface of the earth.

Geologically speaking, the Indian Empire may be regarded as consisting of three parts. There is first the Peninsula stretching southwards to Cape Comorin from its apex at Delhi; it is a remnant of the old Gondwana continent. To the north of this is the second unit, the Indo-Gangetic alluvium, composed of sands and clays, laid down, in geologically recent times, upon what is really a bent-down portion of Gondwanaland. To the north of this alluvium is the third unit composed of three mountain festoons with their convexities directed towards the Peninsula. On the north-west is the first festoon composed of the arcs of Baluchistan and the North-West Frontier Province; on the north is the second festoon, the magnificent arc of the Himalaya; and on the north-east, is the third festoon, composed

¹ L. L. Fermor, 'Preliminary Note on Garnet as a Geological Barometer and on an Infra-Plutonic Zone in the Earth's Crust', *Rec. Geol. Surv. Ind.*, XLIII, pp. 41-47, (1913).

of the mountain ranges of Assam and Arakan and the Andaman and Nicobar Islands.

The northern edge of Gondwanaland is actually on the north side of the Indo-Gangetic alluvium, and lies in the outer ranges of the Himalaya; the Assam plateau may also be regarded as a fragment of this old continent; and as the Indo-Gangetic alluvium rests upon what must be regarded as a down-warped portion of Gondwanaland, we can in fact reduce our elements to two, of which one is a fragment of Gondwanaland represented by the Peninsula of India, the Indo-Gangetic alluvium, the outer ranges of the Himalaya, and the Assam plateau. The other element is represented by the three mountain festoons of the north-west, the north and the east, which appear to result from the overthrusting of Asia on to this fragment of Gondwanaland.

There is a difference of opinion whether this relationship has been produced by the underthrusting of the Peninsula of India against the mountain lands of Asia, or by the overthrusting of the high lands of Asia on to Gondwanaland. The resulting Indian Empire, however, is an approximate geological whole with a crude bilateral symmetry about a N.N.E.-S.S.W. line that is reflected in the geography and orography of the Indian Empire. The exact outer limits of this Empire are, nevertheless, difficult to select on geological and, therefore, geographical grounds, and are dependent upon the details of history; but there can be no doubt that, looked at from a broad point of view, Burma, or at least the western portion thereof, must be regarded as an integral portion of the Indian geological and geographical unit.

General geological factors have thus given rise to a natural unit comprised of a hilly and wooded Peninsula bounded on the west, south and east by seas and on the north by fertile plains, which are themselves limited by bordering mountain ranges to the north-west, north and east. The protective action of these bordering ranges would have been complete were it not for the operation of more local causes, such as faulting and river erosion in producing the gaps known as passes. The existence of these passes has had a profoundly important influence upon the human history of India.

Students of this history are aware that throughout the ages there has been a succession of waves of invading races that have taken advantage of the passes in the high mountain walls, specially on the north-west, but to a small extent on the north-east; and they are aware how each successive wave of human invasion has pushed the remnants of the previous invasions further south into the Peninsula.

The fact that the Peninsula of India is bounded to the southward by seas was until a relatively late date in the history of India a limiting factor to changes in that history by

providing a boundary beyond which the inhabitants could not be driven by further invasions from the north, and also by acting as an obstacle to the arrival of any disturbing invasions from the south. Later, however, this very factor of the existence of sea-coasts, once the Cape of Good Hope had been rounded by the Portuguese investigator Vasco da Gama, provided a means by which invaders from a far-distant part of the world, Europe, were able to reach India. Had, however, the disruption of Gondwanaland never occurred, the Peninsula of India would have remained embedded in a continent and would, consequently, have had no coasts; there would have been no European invasions by sea and the whole history of the country for the last few centuries would have been profoundly different.

As another instance of the manner in which the existence of the sea has reacted upon the history of India, attention may be drawn to the eastern festoon constituted by the Tertiary mountain ranges of Assam and Arakan. Had their continuation through the Andaman and Nicobar Islands to Sumatra and Java not been breached, these ranges would have acted as a barrier between India and Burma almost as effective as that between Tibet and India provided by the Himalayan ranges. The mere fact that the events of geological history have caused this range to be discontinuous with the isolation of the Andaman and Nicobar Islands and the provision of the sea passage from India to what is now Rangoon, led in an inevitable manner to the addition of Burma to the Indian Empire.

To illustrate still further the effect that geology may have upon the distribution of national boundaries, I invite your attention now to the geological map of Europe, though I regret that I have not been able to provide one on a larger scale. A comparison of this map, or of the corresponding orographical map dependent upon it, with the political map of Europe will reveal the extent to which national boundaries in Europe are based upon natural factors. You will observe, for example, how the approximate position of the frontier between Spain and France is determined by the existence of the Pyrenees, which with the seas isolate Spain and Portugal as one natural unit. You will see how Italy may be regarded as another natural unit bounded by the Alps on the north and otherwise by the sea. Similarly the Scandinavian Peninsula, composed of Norway and Sweden, is a natural unit: you will notice also that Finland is geologically allied to Sweden and not to Russia, so that it is not strange that Finland has succeeded in eventually obtaining her independence from Russia, although the national boundary between Finland and Russia is not in agreement with the geological boundary.

It will be noticed on the other hand that it is difficult

to select on natural grounds a precise position for a frontier between France and Germany, as also for the frontiers of many of the countries of Central Europe. This lack of correlation between natural and national boundaries in Central Europe may, in fact, be regarded as the ultimate cause of the Great War, a more proximate cause being the ownership of the coal-fields and iron-ores of the Franco-German frontier lands. The broad truth is that in many parts of Europe nationality is on a smaller scale than geology and is consequently upon a precarious basis: from which it appears, if we may rely upon geology, that national stability will not be attained in Europe until the countries have in many cases been grouped into much larger units. The results of the partition of the Austro-Hungarian Empire as a result of the Great War provide an example of a particularly flagrant violation of nature; and economic grounds alone, it may be predicted, will eventually cause racial considerations to be subordinated to common economic interests resulting from physical factors.

Directing our attention once again to India we find we have here a country of the size of Europe without Russia, containing at least as many different races with at least as great a diversity as in Europe. India is fortunate, however, in that the general geological conditions have caused the inhabitants, in spite of their diversity of race, religion and language, to be welded, after struggles through the ages, into one political unit. As with national boundaries in Central Europe the boundaries between the provinces in India pay little attention in many cases to geological considerations. The province of Bihar and Orissa, for instance, in which we are now meeting, is an excellent example of the violation of natural principles by provincial boundaries. But as long as a central political control remains, it does not matter seriously that the boundaries between our provinces take such little account of natural factors. Were the central control, however, removed and all political relationship to one general suzerain power severed, then the future history of India would again become as confused as it was in the past and as confused as that of Central Europe has been throughout the ages and promises to become again in the future.

I have suggested in the short time at my disposal the profound influence upon the history of a nation and upon the determination of its boundaries that may be exerted by geological factors, how relative national stability appears to be attained in cases where natural boundaries are based on physical features, and how the history of a country in respect of its extent and government appears to become confused and doubtful in cases where national boundaries have been laid down in defiance of physical considerations.

Leaving the general for the particular, I propose now to point to a few precise events and sets of conditions in India

that can be ascribed to particular events in the geological history of the country.

In the first place we may refer to the position of the capital. There is no doubt that the defence of any country is one of prime importance, and that, therefore, the position of greatest internal strategic importance may have claims for selection as the capital of the country. A glance at this map will show you that Delhi, by virtue of its position at the apex of the Peninsula, occupies the most strategic point in India, with reference to the internal peace of the country. For Delhi is at the point where the plains of the Indo-Gangetic alluvium that separate the Peninsula from the Himalaya become most constricted, the point consequently at which it is easiest to defend the fertile plains of the Jumna and the Ganges to the east against invasion from the west, the direction from which most of the major external invasions of the past have come. It is not surprising, therefore, that in the past history of India there have been three decisive battles at Panipat¹ in the plains north of Delhi. It is this position at the apex of the Peninsula that caused Delhi to be the capital home of the Moghal Emperors and their predecessors, and which really caused the removal of the capital of India in recent times from Calcutta to Delhi.

But the welfare of a country does not depend only upon defence and politics. Commerce and industry are also of vital importance and, in so far as they are the true sources of wealth to a country, their importance may transcend military and political factors. It will be seen that a point somewhere in the delta of Bengal, by its connection with the Hinterland of the Gangetic valley and the highlands of Assam, its sea connection to Burma and Southern India, and its proximity to the coal-fields of Bengal, Bihar and Orissa, seems to be a natural site for a commercial and industrial capital; it is because of the existence of these underlying natural factors that Calcutta continues to be the commercial capital of India, in spite of the removal of the political capital to Delhi.

The ultimate factors that have caused the selection of Delhi as the political capital of the Indian Empire with the *de facto* retention of Calcutta as the commercial capital date back to the series of events that caused the break-up of Gondwanaland, followed by the elevation of the Himalayas and the deposition of the alluvium of the Indus, the Ganges, and the Brahmaputra.

Another important item in the sequence of events following the break-up of Gondwanaland was the eruption of the Deccan Traps that cover some 200,000 sq. miles of Western India. For it is the eruption of these lava flows that is the real cause of

¹ Babar defeats Ibrahim Lodi (1526): Akbar defeats the Afghans (1556): Ahmad Shah Durani defeats the Marathas (1761).

the greatness of Bombay. Bombay depends mainly upon the cotton industry, and the latter is dependent upon the fertility of the black cotton soil derived mainly from these lavas. The foundations of Bombay were, in fact, laid, when the Deccan Traps were poured forth, let us say 75 million years ago.

Other events in the modern history of India can, however, be attributed to dates much more ancient than this ; for example, the institution of the iron and steel industry at Jamshedpur in this province. This industry is dependent for its supplies of iron-ore and limestone upon deposits that were laid down in Archæan times, and upon deposits of coal laid down in early Gondwana times. We may ascribe an antiquity to these deposits of iron-ore and limestone of something between 600 million and a thousand million years, and to the coal an antiquity of some 200 million years. The foundations of the iron and steel industry at Jamshedpur were thus laid down at periods ranging from, say, 750 to 200 million years ago.

Numerous other examples could be cited of the dependence of particular events or industries upon past events in the geological history of India : but time does not permit.

The examples given all illustrate the manner in which geology has affected man, without his being conscious thereof : they illustrate the action of cause and effect in which mankind appears as the helpless child of geology.

There is, however, another aspect of our subject in which man derives conscious benefit from his geological heritage by utilising the rocks, minerals and structures now lying at or near the surface of the globe. This may be described as the utilitarian side of geology, and this I have already discussed at some length in my Presidential Address to the Mining and Geological Institute of India in 1922 under the title of the *Utility of Geology to Man*.¹

It is unnecessary to enlarge upon this branch of our subject here, except, for the sake of completeness, to mention that on the utilitarian side geology helps not only in the development of mining and metallurgical industries, but also in many branches of engineering, both in the provision of materials and in structural problems dependent upon the strength and disposition of rocks such as those connected with foundations, with the study of landslips and earthquakes, and with the alignment of railways. Further, as a result of the development of mineral and metallurgical industries, geology becomes the cause not only of revenue to Government in the shape of income-tax and royalties, but also of the creation of a widening circle of employment, starting from employment to miners and smelters and spreading out to employment for the great

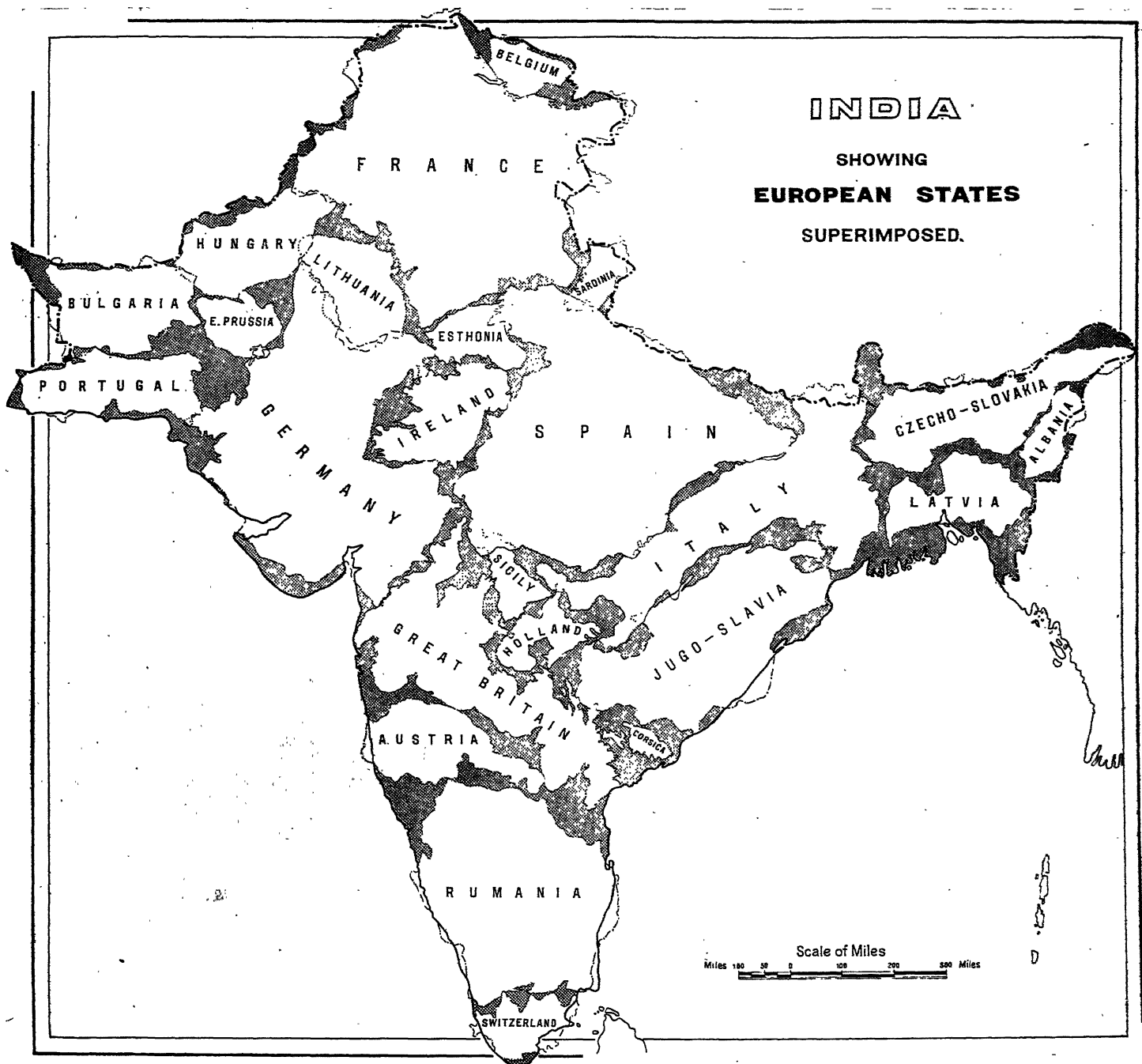
¹ *Trans. Min. Geol. Inst. Ind.*, XVII, pp. 16-40, (1922).

transporting agencies, the railways and shipping companies, to mention only a few of the interests that benefit.

But should the conscious use of geology by man be confined to these directly utilitarian but relatively minor purposes? Should man not, as a result of his studies of the trend and influence of geological factors on a large scale, attempt so to adjust national and international life to these factors as to help the growth of national welfare and international peace; instead of, as so often happens, pursuing, in indifference to these natural factors, courses of action that tend to increase national or international disequilibrium?

It is mainly for utilitarian reasons, however, and partly, perhaps, because in addition it is realised that a country should know herself, that every civilised country maintains a Geological Survey Department for the purpose of ascertaining the factors upon which so much appears to depend.

I have already mentioned the approximation between the size of India and the continent of Europe without Russia. This was brought out forcibly in a map published recently by the *Statesman* (see Plate 1) in which Europe was treated as a jig-saw puzzle, and the countries of Europe, 20 in all excluding Russia, Finland, Scandinavia, Poland, Greece, and Turkey, were fitted into India excluding Burma. I show this map now upon the screen. It is difficult to secure exact figures of the strengths of the geological surveys of the countries in question. But they amount to over 250, of which 78 are employed in Germany and 52 in Great Britain, whilst several of the less advanced countries, namely Albania, Bulgaria, Esthonia, Latvia, and Lithuania, appear to have no geological survey department. In India we have a staff of 24 for the study of the geology of the whole Indian Empire including Burma. Of these about 6 are employed in Burma, leaving 18 for the study of an area equal to that for which Europe provides over 250 geologists. Square mile for square mile, India is, of course, much less wealthy than Europe, but from the figures given above it is seen that if India is properly to know herself, she must contemplate in the future—it may be near or it may be distant—the employment of a much larger number of geologists than at present or than were employed before the recent drastic reduction in the strength of the Geological Survey of India effected as a measure of retrenchment. My faith in the value to a country of the work of geologists, coupled with the fact that in India in particular the accrued yearly direct and indirect financial benefits to Governments—Central and Provincial—is several times the annual cost of the Geological Survey Department, leads me to believe that re-expansion, followed by further growth, will eventually and inevitably be regarded as a vital financial necessity, apart even from the influence of general and cultural reasons the importance of which will be increasingly realised.



By courtesy of the Editor of THE STATESMAN.

I have alluded just now to the cultural aspects of geology. It will be readily apprehended that the study of a subject related so fundamentally to life is admirably suited for inclusion in university curricula. At present the scope for new employment for geologists in India has fallen almost to zero : but this does not mean that geological classes in university institutions should be closed. For young men should be encouraged to study geology not for the purpose necessarily of earning their living thereby, but as a branch of general culture, some knowledge of which is desirable to a man in whatever profession or walk of life he elects to earn his living. It is, in fact, not an exaggeration to say that no university that does not provide instruction in geology can truly and strictly be regarded as a university in the true sense of the word.

I have now reached the end of my address. In attempting to show the importance of geology in the life of a nation, it has not been my intention to magnify this science at the expense of others. All the sciences are inter-related, and geology in particular makes contact with many others, but specially with astronomy, meteorology, botany, zoology, and anthropology, and also with the two sciences that deal with matter in its atomic and molecular aspects, namely physics and chemistry. Moreover, we live in the present : the study of the present aspects of nature is, therefore, of as great importance to us as the study of nature in her historical aspects, with which geology is so greatly concerned. The importance of the study of the historical side of nature lies in the fact that such study helps us to understand how the facts of the present have arisen ; and, because life is a kinetic affair, this historical study helps us to obtain sometimes a glimmering of the future, and even to suggest, however diffidently, the extent to which a measure of control of the future may lie within the grasp of mankind if we will but have the foresight and the courage.

Section of Agriculture.

President :—M. AFZAL HUSAIN, Esq., M.A., M.Sc., I.A.S.

Presidential Address.

ENVIRONMENT IN CROP-PRODUCTION AND CROP-PROTECTION.

We are in the throes of an acute agricultural depression. The conditions of the last few years have shaken our economic fabric to its foundations and there has been a serious dislocation in all spheres of life. Synchronising with this period of terrible depression, gigantic trials on collectivisation and mechanisation of agriculture are in progress in Russia. What economic upheaval and social reconstruction may result from this complex of world conditions and what influence this would have on agriculture in India, it is difficult to predict. The prophets,¹ however, are busy with gloomy forebodings, foretelling 'the end of agriculture as the fundamental industry'. The vision of better, cheaper, more palatable, more varied and more hygienic synthetic food, is conjured before our eyes. We are assured of starch and sugar becoming 'as cheap as sand or salt to-day'. We are even tempted with flesh grown in culture media, which promises to be more delicious and more juicy. Man would depend on artificial silk for his dress and there is the writing on the wall for the cotton-growing countries. Serious attempts with brilliant prospects of success are being made to be independent of Nature with regard to rubber and lac. And so on.

Past experience tells us that natural products stand a very poor competition against the artificials. The disastrous failure of the natural indigo is recent history. By 1897 the Germans had perfected their method of manufacturing indigo cheaply, and India, which held till then the foremost place as a producer of indigo, rapidly lost the industry. In 1897-98 the area under indigo was 1,688,901 acres; by 1929-30 it had dwindled down to 71,100 acres.

Synthetic proteins may yet be distant but artificial silk is certainly a threatening reality. In 1902 the world's output of this commodity was 5 million pounds; by 1927 it had risen to 280 million pounds.

Thus with the Five Years Russian Plan of intensified agricultural production on one side and Earl of Birkenhead's prophecies of the inevitable disastrous end of Agriculture on the other, Agricultural India is between the devil and the deep sea.

¹ Birkenhead, *The World in 2030*.

It must be remembered, however, that we may become independent of wheat and rice, sugarcane and beet-root, potatoes and cabbages, cotton and silk, but our wildest prophet admits that we shall have to depend, for centuries, on plant life as the only source of cellulose—the raw material for the manufacture, alike of artificial sugar and artificial silk. Therefore, whatever may be the future of farming, as we understand it to-day, crop-production is going to stay and is going to develop, perhaps not on the present lines of uneconomic 'petite culture', but as an organised efficient industry, under intelligent, scientific direction. For it would only then be possible to eliminate drudgery and make farming remunerative and attractive.

Moreover, the future interests of the human species demand that industrialisation, as distinct from agriculture, should be checked. The four walls of a factory produce a rigid morbidity—physical, mental, and moral. It is only in open air that man retains that plasticity which is the initial condition for progressive evolution. Surely we do not want to create the situation depicted by Wells in his *Time Machine*. Agriculture, which applies the necessary corrective to unsocial tendencies, is thus bound to play an ever increasing rôle and retain its transcendent importance as the fundamental industry.

If we turn our eyes from this vision of the future of agriculture to the conditions prevailing in India, what a distressing outlook stares us in the face. The statistics of crop yields for India form a very depressing study. The value of the total crop products of British India on the bases of prices prevalent during 1928, has been estimated at 1,200 crores of rupees.¹ That works out at approximately Rs. 46 per acre. According to Sir M. Visvesvaraya—whose estimates are closer to reality to-day—'On the normal pre-war basis, the average production of British India, including irrigated crops, cannot be more than twenty-five rupees per acre; in Japan it cannot be less than a hundred and fifty.'²

No reliable figures of the cost of production of crops are available at present, but on the basis of the above figures of income, farming must be a remunerative profession for only a very few. At any rate it can hardly be denied that the greatest industry of India is carried on most inefficiently.

When one realises that this deplorable condition of Indian agriculture has continued in spite of thirty years' efforts of the agricultural departments, in spite of the introduction of better implements and high yielding varieties, in spite of the growing knowledge of more suitable rotations, and in spite of the better facilities for irrigation and marketing, the horror of the situa-

¹ Central Banking Enquiry Committee Report.

² Total area sown: 255.86 million acres. Jather and Beri, *Indian Economics*, 1930.

tion is intensified and one is assailed by doubts that perhaps as an agricultural country India has no future.

The production of high yielding varieties is the crowning achievement of scientific agriculture. The rapid increase of area under improved varieties is an encouraging sign and it is gratifying to note that the Royal Commission on Agriculture consider that 'the selected varieties of certain crops such as wheat and cotton are now so generally grown in some provinces that the departmental statistics are no longer a true representation of the extent to which they have spread'.

We are often reminded that the improved varieties have added enormously to the income of the cultivator. It has been estimated that the cultivation of three improved types of wheat, Pusa 4, Pusa 12, and Punjab 11, has increased the profits of the wheat growers by at least 15 rupees per acre; and 'the annual dividend on this item of the work of the Agricultural Department is well over a million sterling a year and is rapidly increasing'.¹ It has been established by elaborate calculations that in the *kharif* of 1924, the cotton growers of the Punjab obtained an extra profit of approximately Rs. 3,75,00,000 from the cultivation of improved types of cottons alone.² Similar estimates have been made for jute, rice, and all other improved types. Such statements certainly enhance our self-esteem. On the basis of these calculations the Indian cultivator should be rolling in gold. Unfortunately what glitters is not always gold.

Our outturn of sugar per acre is actually less than one-third of Cuba, one-sixth of Java, and one-seventh of Hawaii. We had in 1927-28, 3,000,000 acres under sugarcane and yet we imported 923,000 tons of sugar and paid 19 crores of rupees for it, and we have created a heavy tariff barrier against foreign sugar to make up for our inefficiency. We are the third biggest

AREA IN ACRES UNDER IMPROVED VARIETIES IN INDIA.

Crops.	1920-21	1923-24	1924-25	1927-28	1928-29	Proportion under improved varieties, 1928-29.
Cotton ..	1,166,807	2,348,882	3,011,447	3,272,638	3,963,991	14.65
Wheat ..	1,807,161	1,398,885	2,282,120	3,517,552	4,126,905	12.9
Rice ..	215,735	603,603	569,908	953,236	976,913	1.1
Sugarcane	10,848	50,604	75,334	268,688	499,890	19.4

¹ Howard, *Crop-production in India*, 1924.

² Royal Commission on Agriculture—Punjab evidence.

wheat-growing country in the world and we seek protection to grow this foodstuff also.

There is no increase in our average yield of wheat, the average for rice has actually gone down, the average for cotton and sugarcane shows a slight upward tendency. These figures may not tell the story very faithfully, but they may at least be taken as a rough indication of the trend.

This stagnant condition of our agriculture is also reflected in the indebtedness of the peasant. The total rural debt of British India has been variously estimated at rupees 600 crores to rupees 1,080 crores. The Central Banking Enquiry Committee place the present debt at a modest figure of rupees 877 crores, and this mostly unproductive debt is increasing at an accelerated rate. The interest on rural debt is calculated at not less than 100 crores of rupees. As Darling says 'A vast majority of our cultivators are born in debt, live in debt, and die in debt'. A landed proprietor of yesterday is a tenant of to-day, a farm hand of to-morrow, and sinks into oblivion the day after. It is worth investigating if unconsciously India is not keeping her agriculture alive by a huge indirect subsidy.

Farming in India as it exists to-day is nothing short of the blackest slavery, and the 'free' slaves must toil under the whip of hunger and shelter—the most terrible slave drivers.

Far be it from me to doubt, even for one moment, that we have not actually produced better varieties. We have wheats which have yielded 40 maunds of grain, and cottons that have given 40 maunds of *kapas* per acre. Nevertheless our averages are distressingly low. There is grossest inefficiency somewhere.

In my opinion the crops and their surroundings are out of gear. We are not able to get the best service from the plants over a larger portion of our cultivated area. In other words, the best of our varieties under the general conditions of farming in India have not the scope to exhibit their efficiency. It is said 'there is no paradise for plants on earth', but India appears to be a veritable purgatory for the high pedigreed cultivated plants. Low soil fertility, violent seasonal fluctuations, and frequent crop failures are the characteristic features of our country.

One feels that we have till now too rigidly maintained that 'the most important agent in crop-production is the plant itself—the plant is the real centre of the subject'. Successful crop-production is essentially the result of the reciprocal reaction between the plant and its surroundings. The plant and what is outside the plant are yoked together and must pull together. Regional distribution of crops—rice and jute in Bengal, wheat in the Punjab and the United Provinces, cotton in Berar, clearly demonstrates the potency of environment. From the point of view of a farmer, to whom a plant is given, it is the environment which is the most important. The object of cultivation

is to produce such conditions for the plant as would enable it to reach its maximum efficiency. Efficient crop-production may, therefore, be defined as the art of bringing about suitable adjustment between the plant and its surroundings.

What are the methods we have pursued so far to determine suitable conditions for crop-production? Our only criterion has been the estimation of yield from varietal and manurial trials, watering and spacing experiments, and so on. Yield, undoubtedly, is the final expression of the efficient interaction between a plant and its surroundings, but mere weight of grain produced does not give us any idea of the complex conditions to which a wheat plant, for instance, has reacted during its life. It is true that a plant integrates the environmental factors and expresses them quantitatively through yield, but to be able to provide those factors for the plant in proper proportion and at the right time one must know what they are.

An illustration of the knowledge obtained from varietal trials will help me to explain my point.

Three varieties of wheat were tested during three successive years in two different rotations—after cotton and after wheat (see statement below). The Punjab 11 gave the highest outturn after cotton, and Pusa 12 the highest after wheat. Yield, it must be remembered, is a compromise between the productivity of a plant and the degree of resistance to environmental factors.

COMPARATIVE TESTS OF WHEAT TYPES AT THE AGRICULTURAL
STATION, LYALLPUR, 1915-16.

(Report of Dept. of Agri., Pb., 1916).

Yield in Grain.

			1913-14.		1914-15.		1915-16.	
			Mds.	Srs.	Mds.	Srs.	Mds.	Srs.
<i>After cotton.</i>								
Punjab 11	21	25	21	12	28	30
Punjab 17	11	22	20	27	28	22
Pusa 12	18	16	20	5	26	20
<i>After wheat.</i>								
Punjab 11	14	23	18	35	22	3
Punjab 17	14	36	17	37	18	33
Pusa 12	17	32	19	0	22	7

What were the factors which made Pusa 12 behave so nobly under adversity (1913-14 after wheat)? Is it a more efficient plant than Punjab 11, because from less available food it was able to produce more? What constitutes this

efficiency? What features of Punjab 11 make it superior to Pusa 12 after cotton? Why did Punjab 17 drop down so badly after cotton in 1913-14? In other words, what was the history of the reactions of these crops towards environmental conditions. You will agree with me that answers to these questions would provide most useful information. Such answers are not forthcoming. Of what value are such trials then? A thorough study of the environmental factors, if carried out, would have been of immense help.

These figures further show that fluctuations in the yields of the same varieties, from season to season, are greater than the differences between the varieties in the same season. And yet we study the crop and not the seasons.

The knowledge obtained from manurial trials conducted on similar lines has been commented upon by the Royal Commission on Agriculture in their report. They say:—

‘Although, ever since the reorganisation of the Agricultural Departments in 1905, manurial experiments have been carried out on every agricultural station in India, it cannot be said that the agricultural experts are even yet in a position to give satisfactory advice to the cultivators in regard to the use of manures.’

The reason is not far to seek. No two seasons are alike with respect to the numerous factors which constitute climate, and no plot of land would be the same during two successive years; and yet by growing crops year after year, under unknown varying conditions, we attempt to know the secrets of the science of crop-production. This method of ‘trial and error’ can never give us satisfactory knowledge. If we continue on these lines, our knowledge of agricultural events, in many cases, can never be more definite than that of a fortune-teller.

Moreover, in a country such as India, where agriculture depends on the vagaries of the weather—which is a most complex combination of activities in the most unstable equilibrium—varieties under trial must be tested not simply on the basis of yield, but also with respect to their ‘ecological amplitude’, in other words the efficiency of performance on level road, up hill and down hill, under various conditions, good and bad. Intensity of assimilation, activity of respiration, resistance to dessication, toleration or immunity from diseases and pests are some of the features which should be properly tested and accurately measured. Having established its ecological limits, a variety should only be recommended for those tracts where suitable environmental conditions are possible. Failure to recognise this in practice, if not in theory, is responsible for our poor agricultural outturns. A plant can only function satisfactorily within a certain range of variations, and at the extreme of these variations it is most sensitive to slight changes. The range of adjustment naturally varies,

and as a general rule the higher the specialisation of a variety for a particular character the more limited its ecological amplitude.

As an instance of this, I take the case of the Punjab American cottons—4F and 289F. They are superior to the improved *desi* in length of lint, but their ecological amplitude is narrower. Thus ever since 1913-14 (the year when 30,000 acres were under the Americans), there have been two general failures (1919 and 1926) and three partial failures (1921, 1927, 1928), and really good years have been only five.¹ We have an actual instance of this. By growing the American types at their farm at Khanewal, the British Cotton-growing Association have lost at the rate of 286 and 175 lbs. of *kapas* per acre per year. The premium on the American varieties undoubtedly made up for this during the early years, but 1926 to 1928 are clear instances of loss both in yield and value.

These are the results from a farm excellently managed, where the usual numerous handicaps, from which our zamindars suffer, have been overcome. It should not be difficult to visualise the condition of the ordinary zamindars. The disharmony between the crop and its surroundings is patent.

It is not suggested that the American types cannot be profitably grown in the Punjab. Even during years of failure certain fields have produced splendid crop. The knowledge of the factors responsible for failures would enable us to grow profitably these excellent types, or evolve those that resist these environmental factors.²

¹ AVERAGE YIELD OF *kapas* IN POUNDS PER ACRE AT THE BRITISH COTTON-GROWING ASSOCIATION FARM AT KHANEWAL.

4F.			289F.	Desi.
1921	..	638	..	844
1922	..	1,030	1,010	1,302
1923	..	1,162	1,170	1,286
1924	..	1,164	1,370	994
1925	..	1,302	1,140	1,632
1926	..	478	426	1,130
1927	..	274	420	884
1928	..	138	668	738
1929	820	860
1930	938	928
Average	..	773	884	1,059

Thomas, R. (1932), *Agric. and Livestock in India*, Vol. II, Part III, May 1932, p. 243.

² Investigations are in progress in the Punjab to determine the adverse factors.

One cannot sufficiently emphasise the point that for this country, endeavours in crop-improvement should be to separate suitable farms on the basis of those characters which are of importance in adaptation to the ecological surroundings, non-living, living and human, in which the improved types are to be grown. In a plant we are dealing with an automatic, self-adjusting, self-adapting machine and unless hard-pressed it will adjust itself to its surroundings, but we have to take care that we do not press it beyond its possibilities. This may necessitate the evolution of a large number of varieties suitable for different limits. This need not frighten us.

Of all the ecological factors the most important for crop-production is the 'soil,'—a complex of factors, living and non-living, which is so little understood and which presents some of the most baffling problems in agriculture. At the same time of all the environmental factors of plants this is the one which is most under human control, and on the proper management of which successful agriculture depends. Further, soil is the factor on which the plant reacts and which it takes a share in building up. Therefore, a proper study of the reciprocal reaction between the soil and the plant has far-reaching consequences for Indian Agriculture. We are told that 'most of the area under cultivation in India had reached its state of maximum impoverishment many years ago', and that 'a balance has been established, and no further deterioration is likely to take place under the existing conditions of cultivation'. A cold consolation. We claim to make profits by growing high yielding varieties on the land which 'had reached its maximum impoverishment' hundreds of years ago. We have to face this cruel fact. How does this inhospitable ecological factor, the Indian soil, in the condition of maximum impoverishment, behave towards the plant and is reacted upon by the plant? Our low yields provide an answer. If soil's reaction could be reduced to sound, one could hear a distinct groan—'I cannot do it'.

Must we not in our efforts at crop improvement give a most serious consideration to this factor of paramount importance—the low fertility of our soil? We must evolve varieties with such high efficiency that on minimum of rations they would do maximum of work. We must understand that those who cannot get bread cannot hope to live on cakes.

Meanwhile we must improve the factor of the food reserve of the plant in the soil. With our extremely limited supply of organic manure, the practical difficulties of enhancing it, the prohibitive cost of chemical fertilisers, our practice of taking away and utilising all that is above the ground for human and animal use, our hopes rest entirely on what plants leave in the soil and the efficient service rendered by the soil micro-organisms. Soil management is to a very large extent an

attempt to utilise the services of these tiny friends by providing them nutrients and stimulants, and suitable conditions of aeration, moisture, and temperature. How very little we know of the reciprocal reaction of the crop, the soil and soil micro-organisms, will be evident from the following illustration:—

'Safe disposal' of rice stubbles containing hibernating caterpillars is considered the most practical measure of eradicating the moth borers of rice (*Schaenobius* sp.), and entomologists recommend off-season cultivation. The agriculturists object to this as it leads to the deterioration of soil fertility. Experiments carried out at the Rice Farm, Kala Shah Kaku (Punjab)¹, have shown that loss of fertility consequent on this method of eradication may sometimes be more serious than the damage caused by the borers.

LOSSES DUE TO OFF-SEASON CULTIVATION OF RICE FIELDS
IN YIELD OF GRAIN.

1928	16.9 per cent.
1929	41.8 ,,
1930	21.9 ,,
1931	7.8 ,,

The ecological factors responsible for this loss in fertility have not been determined. It is known that the living roots encourage bacterial growth in the soil. Is this the factor working in the rice fields after the crop is harvested? If so, how do other crops behave in this respect? A study of the factors responsible for this has far-reaching consequences not only for agricultural entomologists, for whom 'safe-disposal of crop remnants' is the panacea for all ills, but may also change our views about many farm practices.

It shall only be through a thorough ecological investigation of the soil, most particularly of the interaction of the plant, the cultural operations on the soil and the soil population, that a scientific knowledge of soil fertility can develop.

Another important ecological factor, also a function of the soil—is carbon dioxide, from which the plant manufactures carbohydrates. Under normal conditions of light intensity, the small amount (0.03% by volume) of carbon dioxide in atmosphere limits assimilation. In other words, sufficient carbon dioxide is not available for the plant, although there is sufficient solar energy to make use of a larger quantity. Increased amount of carbon dioxide causes greater assimilation, formation of larger quantities of carbohydrates, and higher growth rate. The carbon dioxide, which the crops utilise; is

¹ Dept. of Agri. Pb. Report for the year 1930.

not so much the quantity present in the air as it is the quantity given out from the soil and produced as the result of bacterial activity, respiration of underground parts of plants, and subterranean insects and other organisms. It varies with the type of soil, with the conditions of cultivation, the presence of manure. In unmanured cultivated fields the carbon dioxide may be negative. After the addition of farmyard manure or a complete artificial manure or a combination of the two, the carbon dioxide value may go up above 20% of the average value. Therefore manures do not serve the only purpose of supplying nitrogenous food to the plants, but provide CO_2 also. The amount of carbon dioxide respired from the soil bears a correlation with the yield. How would the production of larger quantities of carbohydrates act upon the root system of the plant, and consequently on the population of the organisms in the soil? [Incidentally it may be mentioned that observations on soil respiration should form an exceedingly useful and quick test of manurial efficacy as they represent the condition of soil fertility.]

The object of experimental ecology is to study the influence of each environmental factor as well as the entire environmental complex on the fundamental life processes, rate of metabolism, growth and reproduction, on the efficiency of which successful crop-production depends. This should form the basis of scientific agriculture.

Every country—nay every tract—has to solve its own ecological problems. Intensity of solar radiation which is at once India's curse and boon is not available to Europe. The extremes of climate to which the Punjab is subject do not trouble Southern India. Conditions of sugarcane growing in the Punjab, where frosts are not infrequent, are different from those of Bihar. Apple orchards of Kulu have problems different from the mango groves of Malda.

As an example of the intricate interaction of the environmental factors, I will take the case of insect pollinators. *Toria* (*Brassica napus*, L., var. *dichotoma* Prain) depends on insects for pollination.¹ In 1928-29 the *toria* crop in the Punjab was poor. Inactivity of the insect pollinators was suspected as the probable cause. On a sunny day one inflorescence may be visited by different insects as many as 153 times, the average of insect visit per inflorescence works out at 71, and per flower at 26 a day. Thus the high normal frequency of insect visits on a sunny day ensures the pollination of every flower and the development of the full complement of seeds in every pod. On a cloudy day the insect visits to an inflorescence may be as few as three for a day of 7 hours (see statement on next page).

¹ Ali Mohammad and others. *Ind. Jl. Agri. Sc.*, I, 1.

FREQUENCY OF INSECT VISITS ON ONE INFLORESCENCE OF *Toria*
PLANT ON TWO CONSECUTIVE DAYS—CLOUDY AND CLEAR.

Hours of the day ..	Number of insect visitors.							Total.
	9-10	10-11	11-12	12-13	13-14	14-15	15-16	
Clear day, 16-xi-30 ..	0	13	20	29	42	28	21	153
Cloudy day, 15-xi-30 ..	0	1	0	0	0	2	0	3

It has actually been observed that the flowers opening on a cloudy day do not set and if cloudiness is prolonged, or synchronises with the daily period of high insect activity, then considerable podless gaps appear on the fruiting branch.

Correlation between the number of cloudy days and precipitation during November and low yield is not without significance (see statement below). Unfortunately daily periodicity of cloudiness, which is a very great consideration, was not recorded.

STATEMENT SHOWING RELATIONSHIP BETWEEN THE AMOUNT OF
CLOUD AND RAINFALL IN NOVEMBER AND AVERAGE YIELD
OF *Toria* CROP AT LYALLPUR.

Year.	No. of cloudy days.	Total amount of cloud in November.	No. of rainy days in November.	Total rainfall in inches in November.	Average yield per acre.	
					Mds.	Srs.
1925-26 ..	14	98	3	0.54	9	27
1926-27 ..	7	42	10	32
1927-28 ..	7	48	10	0
1928-29 ..	16	136	4	2.14	7	22
1929-30 ..	11	84	12	34

The influence of environmental factors—which include pathogenic organisms and insect pests, is of very great importance in crop-protection, because we have long passed that stage when the sole aim of the phytopathologists and agricultural entomologists was to study the disease-causing organisms and insect pests, and undertake direct control measures. The aim now is to investigate all those factors which contribute towards or accompany outbreak of diseases or pests, and thus forestall epidemics and prevent them. The medical men have already

stolen a march over us with their greatly developed science of epidemics. We must recognise that an injurious organism is an integral part of the environment, and is under its influence. Like crop-production successful crop-protection also rests on the foundation of ecology.

Many striking illustrations of the influence of environmental factors on distribution and incidence of disease may be cited. Temperature and humidity of the air bear a close relationship to the distribution and incidence of those diseases which are air-borne, and attack aerial parts of plants. The regional distribution of the Gram Blight [*Ascochyta Rabiei* (Pass.) Lab.] which is confined to N.W.F.P. and the Punjab and its high incidence during those years when there is abnormally high rainfall during February to April are significant.

Similarly the regional distribution and high incidence of bunt of wheat [*Tilletia tritici* (Beij) Wint] shows that it is the soil temperature which is the determining factor. The spores germinate best when the soil temperature is 45°-65°F., and this disease is most severe in Kashmir and hilly tracts of the Punjab, and in parts of Baluchistan. The common Scab of Potatoes (*Actinomyces scabies*) is apt to be more severe in alkaline soil, and in contrast to this, acid soil appears to favour the growth and development of Cabbage Club Root organism (*Plasmiodiophora brassicæ* Wor.). Chemical differences have been found to exist between plants grown under different environmental conditions—intensity of illumination, chemical composition of the soil, etc., and these differences result in differential susceptibility to disease and pest attack. The excess of nitrogen in the soil encourages vegetative growth and delays ripening of a crop and this condition also encourages the attacks of parasites. There is evidence to show that nitrogenous manures make the wheat plant more susceptible to the attacks of yellow rust (*Puccinia glumarum* Erich and Hem.). The application of phosphates favours root formation and hastens maturity of fruit. Thus the life of the crop can be shortened, and escape from diseases and pests effected. Deficiency in potassium lowers the resistance to fungal attacks, and potassium manure is recommended as safeguard of a crop against diseases. Calcium encourages precipitation of phosphatides and pectic material and thus prevents the introduction of harmful organisms.

Perhaps one of the most interesting examples of the influence of environmental factors in plant pathology is the correlation of the degree of pathogenicity of an organism and its association with another organism. Exceedingly little is known about this curious phenomenon. The importance of this in plant pathology and soil microbiology cannot be sufficiently emphasised. Moisture in the soil and soil aeration are known to influence susceptibility to pest and disease attack.

Literature on applied entomology is full of innumerable instances of the direct and indirect influence of various environmental factors on abundance and distribution of insect pests. I would like to say a little about the Desert Locust which provides a striking example of the importance of climatic factors in crop-protection. This pest appears in swarms at intervals spreading over Baluchistan, the Indus plain, the Gangetic plain, the Great Indian Desert (Rajputana), and West Central India, breeds for a few generations and then disappears. During the last six decades such swarms have appeared seven times in the years : 1863-66, 1869-1873, 1876-1880, 1889-1894, 1899-1907, 1913-1917, 1926-1931. One naturally asks :—

- (1) Where were the locusts in the intervening periods ?
- (2) Why do locust swarms appear only during certain periods ?
- (3) Why can the Desert Locust not live permanently over the extensive tract of North-Western India ?
- (4) Why do locusts emigrate from their original home ?

At one time it was the general opinion that India was invaded by the locust hordes which came from Persia and further West across the Western Frontier of the Baluchistan. The surveys carried out during the last two years, under the Locust Research Scheme of the Imperial Council of Agricultural Research, have established beyond doubt that in locusts we have the proud privilege of dealing with, what is mostly, an indigenous material. We have discovered permanent breeding grounds of the Desert Locust in parts of Baluchistan, particularly along the Mekran Coast, in the valley of the Indus and there are indications of other breeding grounds occurring in adjacent territories. Locusts have been breeding at Pasni (Mekran Coast), during 1932, when they were entirely absent from the Punjab and the United Provinces.

The cycle of locust activity may be briefly described thus :— In their permanent breeding grounds the locusts, during the years of lull, survive greatly thinned in numbers. When their numbers have increased and they have acquired sufficient density of population, they emigrate in thick swarms and invade territories hundreds of miles off.

It is evident that before this occurs there must be food enough, in the native home of locusts, for such enormous multitudes to develop. To complete its life-cycle one hopper requires 12.41 gms. of fresh leaf. Swarms have been known extending over many square miles, in many layers deep. It is difficult to form an idea of the enormous living material wrapped up in the bodies of locusts forming such a swarm. A thin swarm one square mile in extent and about 20 feet deep, and having only 25 fliers in a cubic foot, would contain living matter weighing over $5\frac{1}{2}$ lac maunds. This living animal matter must

have consumed 46 lac maunds of vegetable matter to reach the winged stage. Under cultivation 400 maunds of green fodder per acre is considered very good performance. At that rate a small swarm of the magnitude under consideration would require 12,000 acres or 18 square miles of intensive vegetation to develop. In the true home of locust—the desert, a much bigger area would be needed and sufficient plant material can only develop during season of abundant rainfall. Thus a series of successive seasons with good rainfall must occur before a decent swarm can be obtained.

The highest number of eggs obtained from a locust, under observation in cages, has been estimated at approximately 850, and in nature it may be possible to get more. At any rate it should not be difficult for locusts, provided they are given suitable conditions for egg-laying, and abundant food supply for their progeny, to multiply, say, 600 times in a single season, and the population may jump up, from 10 to 3,000 per square mile, within a couple of months, and the second brood in the same year would attain a thickness of 900,000 per square mile.

The simultaneous mass appearance of the Desert Locust over an extensive area, stretching from Morocco and the Sudan to Baluchistan and Sindh in India, shows that the factors responsible for this sudden increase must be similar in all these countries. These factors cannot be local, there must be general climatic fluctuations. Thus there is absolutely no doubt whatsoever that climatic conditions determine the rate of increase in the locust population in their original home, and precipitation is one of the most important factors, as the abundance of vegetation which is indispensable for locust multiplication depends on this. A study of the rainfall of the permanent breeding grounds would enable us to predict the appearance of swarms. Fore-warned is fore-armed. Dry atmosphere on the other hand appears to reduce fecundity, and in dry soil the locust would not oviposit however hard-pressed it may be, and eggs laid would not develop if the soil becomes too dry. The temperature being always satisfactory in this tract, suitable atmospheric and soil humidity determines the period of locust development and the density of locust population.

North-Western India provides excellent conditions for locust breeding in so far as abundant food supply and suitable soil for egg-laying are concerned. Then why do not the locusts make this area their home? Once again one has to look to climatic conditions for an explanation. From observation made, it appears that excessive atmospheric humidity is not conducive to the adult's life. Locusts kept in atmosphere fully saturated with water vapour die within a few days while their normal life is many months. The disappearance of locusts from the Punjab, the Gangetic plain, and further East, is evidently the result of similar conditions. Thus, once again, climatic con-

ditions prevent locusts from making our fertile land their permanent home.

Having found excellent conditions for their rapid multiplications at home why should they move out? At one time a simple explanation, that having exhausted their food supply in their native place they went out in search of pastures new, was sufficiently convincing. It is, however, fairly definitely settled that emigration is not in response to hunger, because the fliers, during the swarming mania, actually move out, day after day, from places rich in food supply. Neither is this migration in search of suitable breeding grounds, because very often locusts leave *en route* excellent surroundings for their progeny. Therefore, some other factor is responsible for this behaviour. The stimulus of moving objects in their neighbourhood, in this case the movement of their kith and kin, perhaps makes them imitate and the band moves, or flight takes place.

The locusts exhibit an interesting response to the influence of crowding, i.e. the association of a number of individuals belonging to the same species. We are familiar with the mob mind, herd instinct, or crowd psychology. The behaviour of an isolated individual is often very different from the behaviour of the same individual in association with others of its kind. A sane, self-respecting, law-abiding, harmless citizen, in the twinkling of an eye, under the influence of environmental factors, may turn into an insane, disreputable, law-breaking, blood-thirsty beast. Perhaps the greater the density of the crowd the more pronounced the crowd behaviour. Individually the locusts are modest, of a retiring disposition, they seek protection in bushes perfectly concealed by their protective green coloration, they are fond of their home and hearth, and are loth to take strenuous exercise; but collectively they are bold, aggressive, with striking non-protective black pattern on yellow background, they spurn away the protection afforded by vegetation and undaunted they face the desert world, surcharged with the ambition of conquering the vastness of space; obstacles cannot stop their march, they must conquer or die in the attempt.

The influence of isolation and association is not limited to their behaviour but extends to their coloration. The hoppers as they hatch may have black spots or may be entirely green, without the black pigment, or they may have less intense markings. All these hoppers, melanic, intermediate or even green, when kept in association, i.e. crowded, develop pigment in the skin. On the other hand, if isolated, i.e. bred singly in separate cages, if born green, they do not develop the black spots, or if born melanic, they lose their spots. Even the darkest individuals under influence of isolation become successively less and less pigmented at each moult and finally become green. This difference in colour is so constantly

associated with thinning and crowding that it has come to be regarded as the distinguishing feature between the solitary and swarming phases of this insect. In the solitary phase the hoppers as well as the fliers lead scattered life, do not form bands, and do not fly in swarms. In the swarming phase on the other hand, the hoppers are gregarious, they make huge bands and are constantly on the move during the greater part of the day. The fliers have similar behaviour and form huge swarms. An environmental factor—association or its absence—is thus able to produce such fundamental changes. And for these hoppers even two is a crowd. So that if one hopper is bred by itself in a glass jar, it remains green or turns green, while if there are even two, they remain black or turn black, provided the cage is not bigger than 1.5 foot each way.

It is possible to produce melanism through other causes, such as an extra dose of carbon dioxide, but the influence of mere association is very difficult to explain. Personal touch seems essential because even when separated by transparent glass partition or wire gauze the influence of isolation usually dominates. We do not yet know the manner in which this environmental factor acts—through the organs of vision, the organs of touch, or the organs of smell?

What external factors produce this internal change which leads to pigmentation is not known, but the presence of black pigment is connected with increased activity of the insect, as exhibited by band movements. Is pigmentation essentially the cause of this activity or the result of it? This question cannot be answered at present.

It is not only coloration which is effected under influence of association or isolation, but the structure of the adults is altered to such a degree that at one time the gregarious phase *Schistocerca gregaria*, Forsk., and the solitary phase *Schistocerca flaviventris*, Burm., were regarded as two distinct species.

What is the significance of all this in applied entomology? When the period of activity has subsided, the locusts would be present only in their original home much thinned, and they would produce green hoppers which would lead a scattered life, their cryptic coloration would perhaps protect them from the attacks of enemies and the species would be preserved. When suitable conditions re-appear, their numbers would increase. When a certain density of population has been attained the black hoppers would develop. That would be the signal for the impending migration. Through a knowledge of the environmental conditions, the migration could be forestalled and frustrated by thinning the population. Thus armed with adequate knowledge of events, by taking timely action over a comparatively limited area, very extensive cultivated tracts could be saved from the ravages of this scourge.

Efficiency of Indian crop-production has not reached a

stage when expensive control operations can be recommended. The margin of profit being low, we must depend on cheap methods of control of diseases and pests, and for that we have to study ecological factors influencing crops and their pests.

No experiment in any branch of agriculture can be considered complete if it does not take into consideration the environmental factors concerned. Foundation of scientific crop-production and crop-protection must be laid on experimental ecology.

I have made an attempt to place before you a few scattered facts to illustrate the importance of ecological studies in crop-production and crop-protection. The complexities of the problems and the difficulties that face us are enormous. Meteorological data as reported have little value in ecological investigations. Accurate information of the conditions in the immediate surroundings of the crops, such as : soil temperature and moisture at different depths, air temperature and moisture at different heights and at different times of the day, temperature on the surface of the plant and inside it, intensity of solar radiation, its periodicity, cloudiness, precipitation, air currents, pressure, electric condition of the atmosphere, physical and chemical composition of the soil and air, general factors, such as climate and climatic rhythms, and many other factors of importance have to be studied and their influence determined.

In experimental ecology the environmental factors have to be simulated and this further presents enormous difficulties. To overcome these all the natural sciences have to be mobilised : physics, chemistry, soils-science, bacteriology, botany, zoology, physiology, and meteorology. It is this aspect of agricultural research in which co-operation between the science departments of the universities and the department of agriculture is most necessary.

I cannot close this plea for a study of ecology in relation to agriculture without saying a few words about the requisite training for research workers in this line. Unfortunately our universities have not yet recognised the true importance of ecology as a branch of knowledge, with wide application and providing excellent mental training. The result is that it is not possible to find young men well equipped for ecological research. It is the function of the Indian universities to supply the departments of agriculture with trained ecologists. Perhaps a beginning may be made by providing facilities for training at one centre.

The future appears bright. The stimulus given by the Imperial Conference of Agricultural Meteorology has had satisfactory response. Bibliography of Literature on Agricultural Meteorology has been prepared, containing abstracts of some

650 papers. We have an exhaustive and up-to-date account of 'Insects and Climate'.¹

The environmental factors acting upon the Imperial Council of Agricultural Research have yielded still more encouraging results and we are witnessing the birth of some rare varieties—Plant Physiologists and Agricultural Meteorologists.

We are told that of the three huge projects to be attempted by mankind in the 22nd century, one would be 'the control and stabilisation of weather over the whole surface of the planet.'² Let us therefore attempt to leave a valuable legacy behind in the form of accurate knowledge concerning plants and animals and their environment.

¹ Uvarov, *Trans. Ent. Soc., London.*

² Birkenhead.

Section of Agriculture.

Abstracts.

STATISTICS.

1. A statistical study of the minimum size of plot deduced from tonnage experiments with cane Co. 205 at Pusa.

M. VAIDYANATHAN, New Delhi.

The standard error of cane yields of 840 sections of 1/480 acre each (30'-3" x 3') and S.E. as % of Mean. Influence of plots of different shapes on S.E. (table). Frequencies of yields for different plot-sizes (graphs). Distribution of S.E. as % of mean for different sizes (graphs). Deduction of optimum size of plot at 1/24 acre (151'-3" x 12') based upon minimum S.E. and ideal distribution.

2. Application of modern statistical methods to field trials.

R. D. BOSE, Pusa.

The application of statistical methods in the interpretation of results of agricultural experiments demands greater attention than is usually paid at present in India. An outline of the important methods and their bearing on the lay-out, etc., of field trials is discussed.

3. The design and conduct of field experiments.

F. K. JACKSON *and* YESHWANT D. WAD, Indore.

Dependable conclusions can never be drawn from field experiments unless they are properly designed and conducted so that the results can be put to statistical examination. To do this much skill, equipment, labour and cost is involved, which limits the output of results.

An attempt has been made to minimise effort and cost by systematisation and simplification for Indian conditions, as has been done elsewhere, notably by Rothamsted workers.

The paper is intended to stimulate interest and to invite constructive criticism and suggestions so that an agreed technique among Indian workers may be evolved, with local reservations as necessary. When this is achieved it will be easier to compare, with confidence, work done at different centres.

The factors involved in the design and control of experiments to study a variety of problems have been considered and discussed. The organisation for team-work and a number of labour-saving devices in use at the Institute are described in detail.

4. Yield trials in rice at the Karimganj Farm.

S. K. MITRA *and* P. M. GANGULI, Jorhat, Assam.

The recent introduction of new statistical methods of calculation in the work of yield trials of rice at the Karimganj Farm has given some interesting results of which a brief note on the comparison of three transplanted *aus* (autumn rice) carried out this year is discussed. Although the arrangement of the plots were more or less systematic they have been treated here as randomised and an effort made to work out

the significance of difference by Fisher's t-test and the method of analysis of variance. Both the systems of calculation have given almost similar results. With the help of the values of 'f' formulated by Prof. P. C. Mahalanobis, it has been shown that the number of replications used in the experiment was quite sufficient to get a significant difference.

5. The present jute position in India. A statistical study of the various factors that contribute to it.

M. VAIDYANATHAN, New Delhi.

Production and demand of Indian jute from 1914 to 1932. Consideration of various factors that influence the jute acreage in India, demand outside, rainfall before the sowing period and prices of jute and its competing crops *aus* and *aman* rice. Correlations between the jute acreage and exports and prices of jute in India during the years 1914-1931. Correlations between arrivals, and (1) exports, and (2) prices of jute in Calcutta for the period 1914-1931. The following detailed correlations are worked out with regard to main jute growing districts in Bengal, Rajshahi, Rangpur, Pabna, Dacca, Mymensingh, Faridpur, and Tippera for the period 1912-13 to 1930-31:—

(1) Correlation between rainfall in March-May and the jute acreage. (2) Correlation between jute prices in July-December and the jute acreage in the subsequent season. (3) Correlation (Total) of rainfall in March-May and harvest prices to jute acreage in the subsequent season. (4) Correlation (Partial) of rainfall in March-May to jute acreage (prices constant). (5) Correlation (Partial) of harvest prices to jute acreage in the subsequent season (rainfall constant).

(6) Correlation between jute harvest prices and $\frac{\text{acreage under jute}}{\text{acreage under aus}}$.

(7) Correlation between jute prices and $\frac{\text{acreage under jute}}{\text{acreage under aman}}$. (8) Correlation between:

$\frac{\text{jute index number of prices}}{\text{rice index number of prices}}$ and $\frac{\text{acreage under jute}}{\text{acreage under aman}}$.

(9) Correlation (Total) of $\frac{\text{jute index number of prices}}{\text{rice index number of prices}}$ and

(i) $\frac{\text{acreage under jute}}{\text{acreage under aus}}$, and (ii) $\frac{\text{acreage under jute}}{\text{acreage under aman}}$. (10) Correlation

(Total) of $\frac{\text{jute acreage}}{\text{aman acreage}}$ and (i) index number of March-May rainfall,

and (ii) $\frac{\text{jute index number of harvest prices}}{\text{rice index number of harvest prices}}$. (11) Correlation (Partial) of (i) above. (12) Correlation (Partial) of (ii) above.

Analysis of variance of the various correlated factors in the above seven districts. Inferences.

6. The effect of fertilisers on the variability of the yield and the rate of shedding of buds, flowers, and bolls in the cotton plant in Surat.

P. C. MAHALANOBIS, Calcutta.

In manurial experiments, the application of fertilisers can affect the yield in two entirely different ways:—(a) the mean value of the yield may be altered, or (b) the variability of the yield may be affected (the mean value also being changed or remaining unchanged). In the analysis of variance, Fisher's Z-test explores only the first effect, i.e.

whether there is any appreciable change in the mean value it being assumed that variabilities are identical. Neyman and Pearson have developed certain tests (which may be referred to as L-tests) with which it is possible to distinguish and investigate both the effects. These new L-tests are discussed in this paper, and are used for a detailed analysis of certain manurial experiments on the cotton plant conducted in 1930-31 by Mr. K. V. Joshi of the Cotton Research Laboratory, Surat. It is shown in particular that for the production of 'flowers', the variability is appreciably changed, although the mean value remains sensibly unchanged.

7. The effect of different doses of Nitrogen on the rate of shedding of buds, flowers and bolls in the cotton plant in Surat.

P. C. MAHALANOBIS and SUBHENDU SEKHAR BOSE, Calcutta.

In this paper, the effect of two doses of Nitrogen namely 40 lbs. per acre and 100 lbs. per acre on the yield of buds, flowers and bolls, and the rate of shedding at different stages in cotton plants in Surat has been discussed. It has been found that Nitrogen definitely stimulates the production of buds, flowers and bolls, and reduces the rate of shedding of buds.

8. Note on the use of the method of paired differences for estimating the significance of field trials.

P. C. MAHALANOBIS, Calcutta.

In field experiments the estimate of the precision of the comparison is sometimes based on the difference in yield between plots taken in pairs. The use of this method, however, can be justified only in exceptional cases, for example when it is possible to pair two adjacent plots. Numerical illustrations are given to show that this method is entirely invalid when the pairings are made in an arbitrary manner.

9. Analysis of varietal tests with wheat conducted at Sakrand, Sind, 1931-32.

P. C. MAHALANOBIS and SUBHENDU SEKHAR BOSE, Calcutta.

Results of varietal experiments with 5 strains of wheat in 8 replications conducted in Sakrand, Sind, have been analysed in this paper.

Although the division of the field into eight blocks did not lead to any reduction in the fluctuations due to systematic changes in soil-fertility, the precision of the comparison was 4.67 per cent. This was sufficient to indicate that E, A and B are better-yielding strains than C or D, but was too large to distinguish between E, A and B on the one hand or between C and D on the other. It is interesting to observe that the presence of 5 Kalar patches within the experimental area did not affect the yield of these plots materially.

10. The effect of the time of application of fertilisers on the yield and the rate of shedding of buds, flower, and bolls in the cotton plant in Surat.

P. C. MAHALANOBIS and SUBHENDU SEKHAR BOSE, Calcutta.

Results of certain fertiliser experiments on the cotton plant conducted in 1930-31 by Mr. K. V. Joshi of the Cotton Research Laboratory, Surat, have been discussed in this paper. The effect of applying 40 lbs. of

Nitrogen in July to certain plants, and the same quantity of Nitrogen in August to other plants has been studied in detail with reference to the following factors:—the production of (1) buds, (2) flowers, and (3) bolls, and the percentage of (4) buds developing into flowers, (5) flowers developing into bolls, and (6) buds developing into bolls. It was found that manuring in July gave a significant increase in the yield of buds and flowers and although it showed an appreciably greater rate of shedding of buds, the increase in the final yield of bolls was also found to be significant.

11. On the randomisation of plots in field trials.

P. C. MAHALANOBIS, Calcutta.

The need and principles of randomisation of plots in field trials for a valid estimate of the experimental errors have been considered in this paper with numerical examples.

12. A note on the variation of percentage infection of wilt-disease in cotton.

P. C. MAHALANOBIS and SUBHENDU SEKHAR BOSE, Calcutta.

The infection of wilt-disease in cotton for different dates of sowing was studied by the method of Fisher's Analysis of Variance. The mean p.c. of infection for June sowing is 21.45, for July it is 16.11, and for August 14.36. The difference in the mean p.c.'s for June and July is found to be significant while that for July and August is not. It is shown that exactly the same result is obtained by employing Student's method of paired differences.

13. Rice and potato experiments at Sriniketan (Institute of Reconstruction, Visvabharati), 1931.

P. C. MAHALANOBIS, Calcutta.

Varietal and manurial tests were conducted at Sriniketan farm (Birbhum, Bengal) on paddy and potato according to Fisher's Method of Randomised Blocks. Three varieties of each were experimented upon and the manures used were cowdung, amophos and ammonium sulphate. The results of the experiments show that of the three varieties of paddy used, red *aus* stands first in order of mean yield and of potatoes the 'Desi variety' comes first with Patna as a close second. The manurial effects do not appear to be significant in either case.

14. Field trials on some varieties of oats, wheats and barley with a statistical analysis of the results.

A. M. MUSTAFA and T. V. G. MENON, Quetta.

1. Yield trials with some varieties of oats, wheat and barley on the Latin Square Lay-out, conducted in the Imperial Institute of Agricultural Research, Pusa, in the winter of 1931, are described.

2. Results are computed according to Fisher's analysis of variance.

3. The varieties of oats under trial were B.S. 1; Hybrid A, B and C. It was found that the Hybrid A, B and C are liable to shatter, in the presence of any early west wind, which reduces their actual yielding capacities. In Bihar and United Provinces where the early west wind is to be feared, B.S. 1 is to be preferred, as it does not shatter. Between the yields of the Hybrids themselves, the differences were not statistically significant, while the differences of B.S. 1 over those of the Hybrids were statistically significant.

4. The varieties of wheat tested were P 4, P 12, P 52 and P 111.

The differences in the yields of P 12 and P 52 over those of P 4 or P 111 were significant. There was no statistical difference in the yields of P 4 and P 111 or P 12 and P 52.

5. The Barley varieties tested were Cawnpore 251, Type 20, Type 21 and a local variety. The differences between the yields of Cawnpore 251, T 20 and Type T 21 with that of Local are definitely significant.

SOILS AND MANURES.

15. Some studies on the wilting co-efficient of the soil in relation to wheat plant.

J. C. LUTHRA and P. C. RAHEJA, Lyallpur.

1. Inward rolling of the leaf over the mid-rib is a characteristic feature of wilting in the wheat plant. This is due to the hygroscopic action of the motor cells of the epidermis of the leaves, which contract as a result of excessive transpiration.

2. Wilting co-efficient of the soil has been found to vary with the (a) growth of the plant, (b) ability of the plant to pass into dormant state during the period of drought and the period for which it can remain in this condition.

3. Wilted plants showed wilting co-efficient ranging from 1.08 to 1.86 per cent., the variation being due to the condition of the plant described in para. 2.

4. Considerable difference has been found between the observed wilting co-efficient and the calculated figure arrived at according to the formulæ of Briggs and Shantz. Probably this is due to the diversity between the soil conditions of the Punjab and the locality where the experiments, on which the formulæ are based, were carried out.

16. Note on soil erosion in black cotton soil.

YESHWANT D. WAD and G. C. TAMBE, Indore.

Serious erosion has occurred within the space of two rainy seasons in the black cotton-soil land of the Institute, in spite of grading, surface-drainage, and protection of margins of fields by grass. Erosion in the drains and grass-borders starts along lines of least resistance, surrounding stools of grass, in dry-weather cracks and in holes and tunnels burrowed by rats and other animals, quickly resulting in deep scouring. Sheet-erosion in cultivated fields causes silting up of lower portions and diversion of the flow of water to form an irregular channel. Prolonged flow in areas fed by sub-soil water-currents is another source of erosion. Once started the irregular channels rapidly lead to destruction of the grading of the field and create holes. Fertility of the soil rapidly goes down and crops become uneven. The probable remedies may lie in adjustments to prevent silt being carried long distances. Such adjustments may include frequent obstructions to the flow of water; low bunds and strips of cover crops.

17. The effect of three years' application of lime on crop growth, soil reaction, and exchangeable base.

M. N. GHOSH, Sabour.

The results of three years' application of lime with or without fertilisers on a plot of Cuttack soil in the deltaic tract of Orissa have been discussed. The added lime in the first year was directly effective in raising the crop yield, but in the two succeeding years, the effect was more indirect, lime being chiefly instrumental in producing an improvement in the sub-soil conditions and in bringing out the beneficial action of nitrogenous fertilisers which without lime failed to show much effect.

18. The time of application of a nitrogenous top-dressing as a factor in determining the yield and quality of grain crops. A preliminary study.

T. J. MIRCHANDANI, Bangalore.

Evidence has been obtained that an early dressing of a nitrogenous manure like the nitrate of soda increases the yield of grain crops without affecting their nitrogen content. Sometimes there may even be a slight decrease on the percentage of nitrogen of the grain. A late dressing, on the other hand, increases the nitrogen content of grain as well as of straw without effecting any appreciable change in the yield. The collection of developmental data of the crop, from its early stages, is essential in order to determine the time of the late dressing as the results are largely dependent in the developmental stage at which the nitrogen is supplied to the crop. The crops under experiment are wheat and ragi.

Concurrently with this, an attempt is being made to interrelate the time of availability of nitrogen from organic manures with the yield and protein content of the grain, when the crop is manured with organic manures only.

19. The utilisation of a neglected source of nitrogenous manure.

S. DAS, Pusa.

Indian soils are generally poor in their content of nitrogen which is an essential plant food for proper crop growth. Consequently, every effort should be made to avoid economic loss to the country as far as possible by making proper use of all nitrogenous manures available in any locality. The wastage of cowdung being used as a fuel and the consequent lesser output of valuable farmyard manure at the disposal of the Indian cultivator are well known. Wastage of oilcakes has also been noticed recently.

Wild apricot trees grow abundantly on an extensive area in the Simla Hills. Their fruits are locally consumed and the oil from seeds having about 40 per cent. oil-content is used for cooking, burning, and as a hair oil. The cake left after extracting the seeds for oil is neither utilised as a cattle-food owing to its bitter taste, nor does it find an alternative application as a manure; it is burnt as a fuel only. The cake containing a considerable proportion of nitrogen, e.g. 6.7 per cent., besides a fair amount of phosphate and potash, its waste as a fuel is thus an economic loss to agriculture.

With a view to find out its possible utilisation as a suitable nitrogenous manure, the cake was subjected to a study of its nitrogen transformation in the laboratory from the biochemical point of view in three different types of soil, e.g. (1) a highly calcareous Pusa soil having about 35 per cent. of calcium carbonate, (2) a non-calcareous Kalianpur soil near Cawnpore, U.P., containing less than 1 per cent. of lime, and (3) a hill soil from Solon near Simla Hills with a fair amount of organic nitrogen, i.e. 0.15 per cent., which is about three times that in the other soils but is not easily nitrified as in the other cases. All the soils had their pH over 7.

In the first two soils about 63 per cent. nitrogen of the cake is transformed into available forms in 7 to 8 weeks' incubation, whereas in the Solon soil 50 per cent. is transformed similarly in 3 weeks' time. This available nitrogen will be conducive to better crop production, and thus the possibility of the cake as supplying a suitable nitrogenous manure to soils is ensured. It is next proposed to confirm its efficacy by actual crop growth in the ensuing cold weather.

20. Determination of nitrogen in soils.

A. SRINIVASAN, Bangalore.

As already shown by Bal, estimates of total nitrogen obtained by the usual dry digestion of soils with sulphuric acid are invariably lower than those obtained by digestion after wetting. The author's observations show that the optimum condition for the most efficient digestion would appear to be that of moistening the soil at the rate of 20 c.c. of water for every 5g. of soil, then adding concentrated acid (20 c.c.) and allowing the mixture to stand overnight prior to digestion. Oxides of iron and aluminium, which are present in all soils, are among the compounds which interfere with the progress of digestion by the usual method.

Pre-treatment of the soil with dilute aqueous solutions of hydrochloric acid or potassium hydroxide, also improves the efficiency of the digestion, giving as good values as the water-treatment while that with aqueous hydrogen peroxide, gives even higher ones. Evidence has also been obtained to show that the concentrated sulphuric acid has much less penetrative power into the soil than the dilute acid or any other electrolyte so that the reason for the incomplete digestion observed when adopting the usual dry method would appear to be that of incomplete wetting of the soil particles by the acid, a condition which persists even after prolonged heating. Further work is being carried out to throw more light on the mechanism of the above and to standardise the conditions of estimation so as to ensure true values being obtained for all types of soils.

21. Nitrogen balance in black cotton soils in the Malwa plateau.

YESHWANT D. WAD and V. G. PANSE, Indore.

Under monsoon conditions on the Malwa plateau the texture of the black cotton-soil deteriorates during prolonged wet periods, crop-growth is seriously checked and yields lowered.

Yields were raised by dressings of safflower cake which improved the tilth though not so markedly as did superphosphate and sulphur, which, however, scarcely affected yields. The nitrogen of the cake seemed to be responsible. Equivalent nitrogen in *karanja* cake gave very variable yields, but always lower than safflower.

These results seemed to indicate differences in behaviour during nitrification. Using ammonium sulphate as a control, this possibility was examined by a special method devised to imitate monsoon conditions in the field.

Safflower cake nitrified steadily and for a longer time, the inference being that cotton-yields are influenced by the steadiness of nitrogen-supply, especially in the later stages of growth.

Under the conditions of experiment very low concentrations of free nitrates were found, due to absorption by algal growth, which seems to conserve nitrates, so reducing losses by leaching and other causes.

22. Effect of maize root washings on the fixation of Nitrogen.

N. D. VYAS, Pusa.

The paper deals with the experiments conducted by the author to study the effect of maize root washings on the fixation of Nitrogen in Ashby's 2 per cent. mannite solution, inoculated with Pusa soil.

The results show that in the flasks treated with maize root washings, the amount of Nitrogen fixed was 15.56 per cent. more than in the control flasks, thereby showing that the maize roots secrete a product which possesses the power of stimulating Nitrogen fixation.

23. Effect of C:N ratio on the decomposition of organic matter and consequent release of plant nutrients in soil.

T. J. MIRCHANDANI, Bangalore.

From a large series of controlled experiments, it is now possible to give a quantitative measure of the effect of varying C:N ratio of the organic matter on the ammonia and nitrate accumulation in soil. It has been shown that, the narrower the C:N ratio of organic matter, the quicker would be its decomposition in the soil and *vice versa*. In pot culture experiments, the crop raised on soil treated with slow decomposing organic manures (i.e. of wide C:N ratio) suffered from nitrogen starvation and the period of the nitrogen deficiency depended upon how far the C:N ratio was removed from the optimum ratio of 16. In other experiments, several mixtures of the same C:N ratio but made up with substances of widely differing chemical composition, gave substantially the same decomposition curves, indicating that the form in which carbon and nitrogen existed made no marked difference in the mode of decomposition of the organic matter in the soil.

It is suggested that the determination of C:N ratio provides a quick method of assessing approximately the manurial value of any organic matter. Carbon was determined by Drenstedt combustion method and nitrogen by the Kjeldahl method.

PLANT GENETICS.

24. Lodging of straw and its inheritance in rice (*Oryza sativa*).

K. RAMIAH and S. DHARMALINGAM, Coimbatore.

The paper deals with the lodging of straw in rice which is an important character of cereals and one with which all the cereal breeders are concerned.

Different types of lodging commonly found occurring in a number of rice varieties grown at the Paddy Breeding Station, Coimbatore, are described. Studies on the morphology of the plant have shown that there is no single factor which could be used as an index of the lodging nature of the straw. The persistent and thick enclosing leaf sheaths of the internodes just above ground level, the layer diameter of the bottom internodes, the thickness of the sclerenchymatous cells at the periphery and near the vascular bundles in transverse sections of the internode, all appear to be indicative of the non-lodging nature of the straw.

The conditions which usually bring about lodging of the crop in the field and the cultural practices usually adopted to avert or minimise damage due to lodging of the straw are described.

The inheritance of the character studied in two sets of crosses between typically lodging and typically non-lodging varieties proves the simple recessive nature of the non-lodging character. The analysis of the figures in the F_2 s of the crosses indicates a genetic association between non-lodging nature of the straw with characters like tillering, duration, and plant height.

25. Inheritance of albino and white-striped characters in rice.

S. K. MITRA and P. M. GANGULI, Jorhat, Assam.

Self-pollinated seeds of apparently pure green rice produce a number of seedlings deficient in chlorophyll year after year. Most of them are entirely chlorotic (albino) which soon die in the seed bed, while a few in

rare cases produce seedlings with white-striped leaves. The latter survive although in a weaker condition than the green plants and produce normal grains. The progenies of crosses show an increased percentage of albinos than the ordinary pure strains.

A few seedlings with white-striped leaves were isolated in the observation plots in 1926 and grown in successive generations. The white-striped character was conspicuous all throughout the vegetative growth and the mature grains were distinguishable by the lighter colour of the inner glumes. One plant, thus isolated, was found to segregate in the ratio of 3 white-striped : 1 albino in the first generation. The albino character was later on eliminated and a pure white-striped strain was evolved.

The white-striped character segregated as a simple Mendelian recessive to green in natural, artificial, and back-crosses.

26. Chromosome studies in some species of *Crotalaria*.

S. RAMANUJAM, N. PARTHASARATHY, and K. RAMIAH,
Coimbatore.

Cytological studies on the *Crotalaria* species, a number of which are found to occur in the Madras Presidency and among which *Crotalaria juncea* is agriculturally important as a green manure and fibre crop have been undertaken.

Four species, *C. juncea*, *C. verrucosa*, *C. retusa*, *C. laburnifolia* were examined for chromosome numbers which was found to be eight (haploid number) in each of the species.

A description of the meiosis in the pollen mother cells is given in detail.

PLANT PHYSIOLOGY.

27. A method of determining different carbohydrates in leaves.

R. H. DASTUR and K. M. SAMANT, Bombay.

A colorimetric method is devised for estimating small quantities of hexoses, cane sugar, maltose and starch in the leaves. By this method one part of hexoses in 100,000 parts of water can be estimated.

28. Rôle of organic matter in plant nutrition.

G. S. SIDDAPPA, Bangalore.

Injection of aqueous extracts of several organic substances into the stem of *Helianthus annuus* led to increased growth of the plants. The effect on flowering was also significant—not only the number but also the total dry weight of the flowers were increased, the difference being most marked in the case of yeast extract.

When 0.05 gm. each of dried yeast, farmyard manure and dried blood were added to acid-washed sand supplied with complete minerals and barley seeds raised therein, marked increase in growth and dry weight of the seedlings was noticed. Experiments are in progress to determine the effect of aqueous extracts of dried blood at different stages of growth.

29. A study of the physiological changes during the process of wilting in 4F cotton, an acclimatised variety of upland American type (*Gossypium hirsutum*).

J. C. LUTHERA and P. C. RAHEJA, Lyallpur.

Wilting of the cotton plant has been studied in two stages, viz. (a) initial wilting, (b) permanent wilting resulting in the death of the

plant. The soil moisture contents at which these two stages of wilting take place have been found to be $3.09+0.23$ and $2.03+0.10$ per cent. respectively.

Wilted plants transpired at a rate 5 to 10 times less than the normal turgid plants. After initial wilting commenced, the transpiration rate remained unchanged up to the stage when drying of the plants set in.

The rate of respiratory activity, as determined in the detached plant, declined with the fall in soil moisture as wilting proceeded. On reaching the stage of death, respiration quickened and continued to rise, although soil moisture decreased.

The leaves of the cotton crop under observation remained wilted from 10 A.M. to 5 P.M. and during this period respiratory activity was very low.

Wilted leaves always showed a higher temperature by about 3.4° C. than turgid leaves.

There was shown a marked rise of osmotic pressure in the juice of leaves between the initial wilting stage and the death of the plant. The osmotic pressure rose from 18.4 to 22.5 atmospheres.

30. A biochemical study of the ragi plant as affected by mineral treatments and seasonal factors.

S. RAJAGOPAL and A. V. VARADARAJA IYENGAR, Bangalore.

H22 variety of ragi was chosen for this study. The different manurial treatments consisted of (1) sodium nitrate, (2) mixture of sodium nitrate and superphosphate, (3) mixture of sodium nitrate, superphosphate and potassium sulphate. The necessary controls were run. H22 is a seasonal variety and the sowing was done towards the end of July. The seeds germinated in five days in all cases but the subsequent growth was influenced by superphosphate.

Tissues of roots and above-ground portion were subjected to chemical analyses for carbohydrates, total nitrogen, ash and ash constituents. The tissue fluids were analysed for pH, electrical conductivity, total solids, total nitrogen, potassium and phosphorus. The influence of season on the composition is discussed.

31. Effect of ions on the growth of plants.

S. S. BHATNAGAR, D. N. GOYLE, and K. G. MATHUR, Lahore.

Effects of a large number of metallic ions on the growths of arhar, maize, and jowar have been investigated. Of these uranium, thorium, and cerium are found to have an accelerating effect while silver, copper, and lead showed a depressing effect on the growth. Experiments have been performed in culture solution where similarity of conditions could be very strictly controlled. Some of the results have been confirmed in small fields.

SOIL MICROBIOLOGY.

32. The plate method of counting soil population.

R. RAJAGOPALAN, Bangalore.

The plate method of counting soil micro-organisms has not so far proved satisfactory for there is no medium suited to all species of micro-organisms in any soil. Platings carried out with various specimens of soils on different media, show that in addition to the general observation with regard to certain groups of organisms being favoured by particular class of media, there is also further distinction in that certain sub-varieties of organisms belonging to the same group are favoured to a greater extent by certain of the special media than by the others. A further difficulty

is presented by the fact that colonies appearing on the dishes disappear after about a week, becoming first transparent round the edges.

It is found that preliminary soaking of the soil in water or saline for 1-3 hrs. always results in increased counts being obtained.

CROP PRODUCTION.

33. Effect of varying moisture conditions on the growth of rice in typical light, medium and heavy soils, of the Central Provinces.

D. V. BAL and R. N. MISRA, Nagpur.

An account of pot culture experiments on the growth of rice in light, medium and heavy soils, from the rice tract of the Central Provinces has been given.

These experiments clearly indicate that if heavy rice soils are kept submerged under water, the growth of rice is adversely affected and the yields are considerably decreased. If, on the other hand, water is applied to such heavy soils, only when required, a normal yield of paddy is obtained.

The behaviour of rice in medium soils is of the same type as described in the case of the heavy soils, but it is not of the same order.

Both the types of water treatments seem however to suit quite well to the paddy crop in the case of the light soils.

34. Studies on soil conditions as affecting the growth of sugarcane in the district of Saran in North Bihar.

M. N. GHOSH and H. N. MUKHERJI, Sabour.

Previous papers on this subject described the unfavourable effects, on the growth of sugarcane, of a high concentration of soil salts in a comparatively dry year and of leaching of light soils in a particularly wet year. Further studies, this season, have revealed that this particular kind of unhealthiness (yellowing) does not take place in the hot weather when soil moisture is in defect, and salts are far more concentrated near the surface. It occurs during a period of clear sunny weather after one or more heavy showers of rain when the sunshine and the abundant soil moisture make for very rapid growth. Such growing canes make a heavy demand on the soil for available nitrogen which quickly runs short. Soils which have a large accumulation, at all depths, of salts of the more deleterious kinds and have a high pH value, are comparatively heavy in texture, have defective aeration, and often imperfect moisture during the break in the rains. Nitrification becomes less active and the seat is often at a depth beyond the reach of the secondary roots. In sandy soils, leaching effects of heavy rain are obvious, particularly if long continued. Unable to receive an adequate supply of available nitrogen, the leaves turn yellow; growth stops entirely; and a rotting of roots takes place. The sick plants in the initial stage contain more phosphoric acid, potash, and soda, but often less lime, and have characteristically a lower amount of nitrogen. There is also a large storage of carbohydrates in the yellow leaves, so that the ratio C : N is very much greater in them than in the green plants. This unbalanced ratio causes a physiological disturbance resulting in yellowing. Cultivation and irrigation revive the plants, but a far quicker response is obtained to manuring with nitrogen or nitrogen and phosphoric acid. The solution of the problem thus turns to quickly creating an increase in the activity of nitrification in soils having a high pH or in light soils according to the season.

35. Soaking sugarcane setts—its effect on germination and growth. Part I.

K. L. KHANNA, Museri, Bihar and Orissa.

The following treatments were tried for soaking sugarcane setts of the variety Co. 213 keeping in view economy and ease of availability :—

(i) Water alone, (ii) Soil extract (10 lbs. in 50 gallons of water), (iii) Lime saturated solution, (iv) Lime (saturated solution) in combination with magnesium sulphate (1 lb. in 50 gallons of water), (v) Cowdung extract (10 lbs. in 50 gallons of water), (vi) Ashes extract (10 lbs. in 50 gallons of water).

As a result of this preliminary investigation indications were obtained that the soaked series gave higher germination percentage, more vigorous growth, greater number of tillers per plant and heavier crop at harvest time. The best results were obtained in the case of soaking with lime saturated solution in combination with magnesium sulphate, the increased yield over control being 23.4 per cent. Record of fresh weights at different stages of growth also indicated the superiority of the plants soaked in the above-mentioned materials over the unsoaked one. Maximum tillering in cane occurred during the dry weather. Mortality of mother shoots was much less in the soaked series though tillers of the 'b' order succumbed heavily during the rains.

Trouble from white ants was much less marked in the soaked series than in the unsoaked one.

With regard to the root development the soaked series were characterised by (i) early development of shoot roots, (ii) greater penetration during dry weather, (iii) quicker response to rains, and (iv) heavier mass near base of the plants at maturity.

A short discussion is devoted to explain the results obtained from soaking.

It may, however, be pointed out that the results relate to one year's experimental work in a single series of plots, due to which it has not been possible to treat the results obtained statistically. Further work on more accurate lines with regard to its statistical analysis is contemplated in the coming two or three seasons, when a final report on the subject will be presented. The justification for presenting this paper is the interesting nature of the results obtained and their far reaching effects, if confirmed elsewhere.

36. Rootzone in sugarcane stalk—its activity and development.

K. L. KHANNA, Museri, Bihar and Orissa.

Rootzone in cane is the region immediately above the internode and varies a good deal with regard to its width in different varieties and different groups of canes. The number of root eyes present does not seem to be in any way correlated with the width of this zone, though their number seems fairly constant for a particular variety or group.

Not all the root eyes, present on the rootzone, develop during the germination stage and varieties differ in the matter of reserve of dormant root eyes which they strive to maintain under all ordinary circumstances. There is a comparatively less reserve in thick canes than in the case of indigeous thin canes, wild saccharums, and co. canes.

As a result of experiments where certain number of root eyes were artificially removed, it was found that the general tendency on the part of the setts to maintain a reserve for future need is kept up.

The experimental data are appended, and they suggest that there is no disadvantage in planting rooted setts, which are at times so common, especially when the harvest is preceded by heavy and late rains,

provided the material is otherwise sound and more than half or half the normal number of incipient root eyes in dormant state is present.

37. Multiple buds in sugarcane—their inheritance and growth.

K. L. KHANNA, Museri, Bihar and Orissa.

Abnormal stalks with some single, double and multiple eyes at each node were come across and this opportunity was taken to study the progeny of such diverse material with regard to their hereditary behaviour and growth capacities.

As a result of the investigation it was found that the abnormal parent nodes gave rise to normal stalks with single-eyed nodes, suggesting thereby that these abnormalities are not inherited. Other considerations such as (i) the development of one abnormal stalk in a clump of eight or nine stalks produced from a single budded parent node, (ii) the inconstant nature of the abnormality on the abnormal stalk, and (iii) the fact that the clumps showing variations are either over-stimulated or suffer a check in growth at some stage, also give rise to the possibility of this variation being due to some physiological condition of the nature of 'adverse' growth factor.

Double-eyed nodes gave a higher germination percentage and showed an accelerated rate of growth in the early stages, while later on their growth rate slackened and they were overtaken by the single-eyed nodes. Multiple-eyed nodes produced rather dwarfish and unhealthy plants. The number of tillers per plant was also very much restricted in the latter case.

Such abnormal material therefore should not be planted.

38. Sugarcane growing in lands rendered saline by sea water.

M. N. GHOSH, Sabour.

The bad effects of flooding the land by sea water are described. Usual crops do not grow in such lands but sugarcane, variety Co. 205, can make a growth though it yields a juice of low richness and purity, and assimilates so much soda salts from the land that the *gur* (raw sugar) made from it has a distinct salt taste. Irrigating the land makes the juice in some lands of worse quality, but treatment of the soil with lime salts particularly with gypsum improved the quality of the juice and the quality and taste of the *gur* considerably. The results obtained in one year were very encouraging and suggested possibilities for permanent improvement of land.

39. Sugar made in cane and not in factory.

S. C. BOSE.

India annually imports sugar worth about twenty crores of rupees. The imposition of duty of Rs. 6-10 per maund is encouraging to indigenous sugar industry. The cost of cane required for a maund of sugar is Rs. 2-10 in Java, whereas, in India it varies from Rs. 3-8 to Rs. 6. Supply of cheap cane is essential to stabilise this industry.

The yield of sugarcane mainly depends on available nitrogen in the soil. About 70% of plant foods, taken up by cane, is stored in the tops and green leaves which can be returned back. The additional requirement can be met by judicious green manuring.

Poor extraction causes an annual loss of about 12 crores of rupees. This is ascribed to weak bullocks by Indian Sugar Committee, and they suggest a substitute (Power-driven crushing-mills) for bullock-driven

mills. A single high pressure will hardly extract more than 70% sucrose and, therefore, a simple single extraction is more responsible for the loss.

By double pressing and simple imbibition in a three-roller bullock-driven mill, 80% sucrose was extracted but even 'roller settings' in such a case were not trying on bullocks. This additional extraction would mean 7 crores of rupees more for cultivators.

40. Toddy palm as a supplementary source of sugar in Bihar.

S. Roy, Sabour.

In Bihar palmyra palms are tapped only for toddy—a drink obtained from its juice by fermentation. In some parts of Bengal and Madras there is a thriving industry of making brown sugar from the unfermented juice of palmyra palms. In Madras a good quantity is converted into white sugar also. The writer puts up a strong case for carrying on this industry in Bihar.

41. Some factors influencing the cotton crop in the Malwa plateau.

YESHWANT D. WAD and V. G. PANSE, Indore.

Under the soil and weather conditions of the Malwa plateau American varieties of cotton do not thrive as well as the *desi* varieties. Quantitative study of their root-development during growth and in varying environment showed that:—

The former had a profuse lateral development of horizontal superficial roots: the *desi* types had their laterals obliquely distributed to greater depths.

Loose soil, drainage and aeration stimulate late root-development, while compact soil and water-logging check it.

The region of root-activity follows moisture movement.

The roots of *desi* varieties quickly adapt themselves to changes of environment, those of the Americans do not.

Leaf-roll and red-leaf of American varieties cannot be associated with humid conditions or other causes hitherto suggested. Lower acidity of sap seems to be one factor causing red-leaf. The water-content of leaves affected by leaf-roll is less than that of healthy leaves. Poor root-development and activity, and compactness of soil in the root-zone are definitely associated with leaf-roll and red-leaf, which seem to result from disturbances in plant nutrition.

42. Cultivation and Curing of ganja in Bihar and Orissa.

M. ALAM, Sabour.

After giving a preliminary account of the three forms of Indian hemp (*Cannabis sativa*) namely:—Bhang, Charas, and Ganja, indicating the characteristics of each and pointing out how one form differs from the other, a detailed account of the cultivation and curing of crop as recommended for this province has been given.

The circumstances under which the cultivation of ganja has been taken up in this province and the increase in the revenue of the province by growing them under license has also been pointed out. The province of Bihar and Orissa had till recently been dependent on the ganja manufacture at Naugan in Bengal with the result that several lakhs of rupees were spent annually in importing this drug from Bengal. The detailed method of cultivation, etc., is based on the experiments carried out in Botanical Experimental Area, Sabour, which have practically

established that ganja can be grown in this province with practically as much success as in Bengal.

The account given is divided under three heads namely:—
(a) Cultivation, (b) Floral structure, (c) Curing.

Under cultivation, the type of land required; the manure recommended and the number and period of ploughing, etc., have been pointed out. The preparation of nursery seed beds, their form and size, the seed rate, etc., have also been given. The age and size of seedling for transplantation and the methods to be adopted in actual transplanting are indicated in some detail. Finally the general care of the plant after transplantation up to the time when flowering starts and the number of irrigations required has also been given.

Under floral structure, the botanical details of the male and female flowers with necessary illustrations is given and the methods for the identification of male plants at as early a stage as possible and their removal from the field at the proper stage is pointed out. In growing ganja the most important and vital process is the removal of all the male plants from the field, as soon as any indication of their being so is noticed. The ganja growers find greatest difficulty in carrying this out satisfactorily and hence this part has been dealt with in great detail.

Finally the method adopted in the manufacture of the ganja of commerce has been given under the head 'Curing'. As there are two types of ganja used in different parts of the province, namely (a) flat, and (b) round ganja, the methods of manufacturing them are dealt with separately. The manufacture of flat ganja, as actually practised at Sabour, is described in detail and illustrated with photographs showing the different stages in its manufacture. The whole process takes about a week to yield the final product for marketing.

43. Rahar sterility.

M. ALAM, Sabour.

A special type of sterility that is being noticed for the last few years in the Rahar crop of these tracts is described in detail. The characteristic features of this sterility are:—

1. Dwarfing of leaves.
2. Formation of leaves in clusters resulting in a bushy habit.
3. Want of normal green colour of the leaves which are yellowish-green.

These features are accompanied by suppression of flowers and fruits which may result in extreme cases in complete sterility.

A detailed study of this sterility shows considerable variation in its amount in different Rahar types, but it is found that the relative sterility of the different types studied is more or less constant from year to year, and that certain types show a comparatively high percentage of sterile plants while others show a very low percentage irrespective of the soil and climatic conditions. It has also been noticed that there is a negative correlation between the sterility percentage and the yielding capacity of a particular Rahar type. This relationship is, however, not so definite as the yielding capacity of a variety depends on so many other factors but this much could safely be concluded that the occurrence of the sterility to any great extent in a particular type of Rahar is sure to bring down its yield considerably.

It is also found that while certain types of Rahar are practically immune to this sterility, there are others that are highly susceptible, thereby indicating that there is an inherent capacity in certain types to resist this sterility. In cases of susceptible variety it is further found that the plants that are apparently free from sterility may give progeny some of which are again sterile. These conclusions are of great importance

from economic point of view as they suggest the lines on which future selections to eliminate this type of sterility must be based. The selections must be made from these immune types.

ELECTRICITY AND AGRICULTURE.

44. Improvement of cotton cultivation by electrocultural methods by increasing a resistance to and eradication of pinkboll worm and root rot.

S. S. NEHRU, Naini Tal.

Successful tests have been made in different series and centres.

45. Improved growth of exotic and unseasonal plants by electrocultural treatment.

S. S. NEHRU, Naini Tal.

Plants of different sections such as fruit-trees, economic plants, shrubs, bulbous plants, native to Bangalore, South India, were transported to North India and grown at different centres and at different altitudes. The above treatment has elicited a powerful response results of which are communicated. There are 9 kinds of fruit trees, 9 economic plants, 21 shrubs, 7 trees, and 6 bulbous plants.

46. Improvement in quality and yield of certain vegetable crops affected by radiomagnetic treatment.

S. S. NEHRU, Naini Tal.

The vegetables which have given powerful response are pumpkins, chillies, beans, carrots, Indian corn, peas, etc. This is confirmatory of and in continuation with a series of similar tests reported in previous papers and published in U. P. Agriculture Department Bulletins, Nos. 53 and 61.

47. Differential response of certain cereals, legumes, flowers, oil-seeds, etc., to varied kinds of radiomagnetic, violet-ray and sparking treatment.

S. S. NEHRU, Naini Tal.

The positive results obtained here not only fix a technique of optimum value for the practical farmer but also contribute to a study of the theory.

48. Tests on the sandal-wood plant.

S. S. NEHRU, Naini Tal.

49. Cure of mildew in the rose plant by radiomagnetic and sparking treatment.

S. S. NEHRU, Naini Tal.

50. Response of sweet peas to electrocultural treatment.

S. S. NEHRU, Naini Tal.

51. Treatment of buds and flowers (Roses, dahlias, cosmos) with weak currents.

S. S. NEHRU, Naini Tal.

PLANT PATHOLOGY.

52. Studies on the nature of the causative agent of the virus diseases of plants.

S. V. DESAI, Pusa.

A severe epidemic of the mosaic disease of tomatoes occurred in Pusa in 1931.

Usual methods of isolating any organism that may be associated with the diseased tissues were tried without success.

Pieces of the stem of the diseased plants with exposed surface thoroughly sterilised were placed on tomato extract agar and on prolonged incubation a peculiar kind of growth developed all round the tissue. The chief characteristic was that small circular clear spaces were visible in the growth. Appearance of these transparent areas was similar to that of plaques obtained by action of the bacteriophage on organisms, and it was presumed that virus-bacteriophage was intimately associated with the organisms.

Repeated attempts by diverse methods were made to free the organisms from the associated bacteriophage without success.

Action of the juice of the diseased plants passed through sterile filter candle was tried on these organisms and serial passages, by filtering the inoculated suspension through filter candle and inoculating a fresh suspension with a small quantity of the filtrate, were carried out to enhance the virulence of the virus-bacteriophage at the expense of these organisms. Slight dissolution was noticed.

Inoculation experiments with suspensions of the serial transfers in which the virus juice was diluted to $1:10^{16}$, $1:10^{30}$ and $1:10^{44}$ were successful, showing thereby that the virus principle multiplied in vitro either with or at the expense of the organisms.

The organisms appeared to be pleomorphic but on cultivation for sometime an ordinary agar assumed a constant and well-defined form. Biochemical reaction of the organisms were studied, the characters of which resembled those of *B. cereus*.

53. Occurrence of the red stripe disease of sugarcane in India.

S. V. DESAI, Pusa.

The occurrence of the red stripe disease of sugarcane has been established for the first time in India.

Red stripe disease is characterised by two definite types of lesions, (1) that caused by infection of the leaves, and (2) that caused by the infection of the growing point. Long needle-like red stripes may be formed in any portion of the leaf blade but generally they appear at or near the base of the leaf blade. They are bright red and follow the course of the vessels. They often coalesce and form a broad lesion. As the leaf matures these lesions assume chocolate-brown colour. Lesions on the growing point bring about the top-rot conditions. On splitting open fine needle-like red lines could be traced in the unfurled leaves reaching the growing point.

The disease is caused by bacterial infection. The causative organism has been isolated. The Biochemical reactions differ slightly from those of *Phytomonas rubrilineans* and *Phytomonas rubrisubalbicans*, which are known to cause the red stripe in other sugarcane-growing countries.

Organism is usually associated with a species of *Fusarium* in the diseased tissues but inoculations with the *Fusarium* alone failed to reproduce the disease.

Artificial production of the red stripe and top-rot condition is induced very quickly by inoculation of the organisms and the *Fusarium* together.

The organism alone is also able to induce red stripe and top rot but rather slowly. The *Fusarium* alone does not produce the top rot but local lesions are usually produced. These lesions are quite distinct in appearance from typical red stripe lesions.

This disease occurs in young canes and under humid and warm conditions causes much damage.

54. 'Yellowing' in sugarcane in North Bihar.

N. V. JOSHI, Pusa.

Yellowing of canes is a new disease of canes observed in North Bihar only in the last few years.

None of the plant parasites, e.g. insects, fungi or bacteria, has been definitely associated with the yellowing.

It appears to be a deficiency disease caused by lack of plant food.

Preliminary experiments made to check the yellowing in cane have shown that one application of Potassium sulphate at the rate of 50 lbs. K_2O to an acre revived the yellowing clumps treated two to three weeks after the treatment.

The success of other treatments, which revived a certain percentage of the treated clumps, is believed to be due to the release of Potassium from the soil complex by base exchange.

55. A preliminary note on an abnormality of Punjab American cottons.

MOHAMMAD AFZAL, Lyallpur.

A growth abnormality in cotton is described. The affected plants appear to be very similar to plants attacked by Stenosis or smalling and the same name has been tentatively given to the disease. All the organs of the affected plants are reduced in size, the leaves are discoloured and show mosaic patterns of lighter coloured areas. There is a very high shedding of buds and bolls. The few bolls which come to maturity are very small in size and give only a few small sized seeds and yield very short and weak fibre. The afflicted individuals are scattered all over the fields and this is one of the characteristic features of an attacked field. It has been noticed that the disease attacked the plants at all stages of growth up to the cessation of elongation in height and was very virulent during September. The root system of the affected plants is also very much reduced.

It has been shown that the disease is neither seed-borne nor hereditary and there are indications that it is a virus disease transmitted through the agency of some insect.

American cottons only are affected, while the indigenous cottons are immune.

56. A *Teichospora* on Bajri.

V. LIKHTE, Baroda.

A *Teichospora* is observed on ligules of Bajri plants growing on the Agricultural Experimental Station at Baroda. The connection between these fungi and ants is very well known. As it occurs only at ligules, there might be a possibility of some sugary secretion at these spots only by which the earliest visitors—black gnats—are attracted and through

their medium this fungus might be getting introduced on the plants. The sooty matting prepared by the mycelium remains attached only to the surface portion and can be easily scraped off. The Pycnidial production is profuse and takes place in the ordinary way. The peculiarity, however, lies in the formation of an ascus and only one ascospore therein. The production of this ascospore is very similar to that taking place in the genus *Thelebolus*. Perhaps this may prove an affinity between the two.

So long there had been only four sorts of fungi known to be occurring on *Pennisetum typhoideum* (Bajri), viz. *Acrothecium penniseti*, *Puccinia penniseti*, *Sclerospora graminicola* and *Tolyposporium penicillariae*. This species of *Teichospora* is, therefore, a new addition to these already mentioned fungi on Bajri.

57. Some new methods for control of loose smut of wheat (*Ustilago tritici*).

J. C. LUTHRA, Lyallpur.

The two methods which have been worked out for control of loose smut of wheat, viz. (1) exposure of wheat previously soaked in water to sun's rays, (2) raising the temperature of water contained in a cylinder exposed to the sun and soaking of infected wheat in it, are briefly described in the paper.

Experiments carried out for testing the methods are given. The results show that while the untreated wheat produced on the average 6 per cent. smutted plants, the treated seed was altogether free from smut.

AGRICULTURAL ZOOLOGY AND ENTOMOLOGY.

58. Further experiments on the root-gall nematode *Heterodera radicumicola* Greeff in South India.

P. N. KRISHNA AYYAR, Madras.

The root-inhabiting nematode *Heterodera radicumicola* Greeff has, for several years past, been known to be the cause of a common and widespread plant disease in South India. The history of the disease with an account of the biology of the parasite, its host-range and a few control measures have been described by the writer in previous papers read before this Congress in 1925 and 1932. The present paper presents the results of his more recent studies on the subject.

The paper, in its first part, deals with certain experiments on the host-preferences of the parasite and sets forth the relative susceptibility or immunity of a number of common economic plants. The second part presents the results of experiments conducted to determine the nematode content at different depths in South Indian soils. The paper concludes with an account of some experiments for testing the efficacy of a few chemicals in eradicating the pest from infested soil. It has been found that the double treatment by Potassium Cyanide plus Ammonium Sulphate is the most efficacious under the conditions pertaining to this country.

59. A study in correlation between the intensity of hairiness of some cottons and insect pests.

J. C. LUTHRA and I. S. CHEEMA, Lyallpur.

In the Punjab two insects, namely, (1) Jassid (*Empoasca devastans*), and (2) White Fly (*Bemisia gossypiperda*) occur commonly on the leaves of cottons. They are found both on the indigenous types and on varieties

of American types (*Gossypium hirsutum*). But the incidence of attack has been found to vary a great deal in the different varieties particularly of the American cotton group.

Greater injury is done to the leaves of varieties, which are comparatively less hairy. Varieties, the leaves of which are densely covered with hairs, are damaged very little.

A statistical study has been made of the number of hairs per square centimeter borne on leaves on seven selections of American cotton. They have shown a range of 220 to 660 hairs per square centimeter. In the case of Desi cottons, which are least attacked, the number is, on the average, 1,200 for the same area.

Percentage of leaves injured by Jassids has been worked out and varies from 10 to 78.

Coefficient of correlation between hairiness and intensity of damaged spots borne on the leaves has been worked out at -0.77 ± 0.16 . It has been ascertained by these studies that with the increase of hairiness leaves become less liable to damage by these insects.

60. Anatomy and development of Bruchid beetle.

DURGADAS MUKHERJI and M. A. HAKIM BHUYA, Calcutta.

The Bruchid beetles are of considerable economic importance as they cause great damage to stored pulses. The life-history of these beetles has been investigated from time to time by several authors, but a complete account of their anatomy and development is lacking. The present authors have therefore worked out the anatomical and embryological details of species infesting the stored pulses obtainable in Calcutta. Special attention has been paid to the mouth-parts and digestive system of the larva boring and feeding on the pulses and the reproductive system of the adult. Sexual dimorphism is also noted.

61. Insect pests noted on oranges in the Northern Circars.

V. MARGABANDHU, Coimbatore.

The object of this paper is to set forth some of the observations made with regard to citrus pests noted in the Circars. Among the pests of citrus, fruit-moths may be considered as the major pest of citrus. It levies a heavy toll by causing fruit-fall in the gardens. There are some leaf-eating ones which may be considered as serious on the nurseries. They are the different species of *Papilio*:—*Papilio demoleus* Linn., *P. polytes* Linn., and *P. polymnestor* Cram; the citrus leaf-roller:—*Tonica zizyphi* Stn., and the Lycænid *Chilades laius* Cram. The citrus leaf-miner *Phyllocnistis citrella* Stn., which mines the leaves is also a serious pest among the seedlings. In addition to these there are several other pests of minor importance noted in this paper.

After giving a short introduction by way of a short paragraph on citrus cultivation in the Circars, this paper deals with the pests, giving in each case details regarding life-history, habits, nature and extent of damage, seasonal distribution of the pest, brief descriptions of the pests themselves and methods of control wherever possible.

The paper stresses upon the application of cultural methods of control to mitigate severe infestations.

62. Some important insect problems connected with the cultivation of rice in S. India.

T. V. RAMAKRISHNA AYYAR, Coimbatore.

In this paper it is the writer's idea to describe briefly the nature of some of the main insect problems connected with paddy in South India

and indicate the present position with regard to the different lines of investigation of such problems.

With a few preliminary paragraphs on the general aspects of the subject, such as the different kinds and habits of paddy insects, their incidence and distribution in the different parts of South India and on the study and control of paddy insects in general, the author briefly deals with the important pest problems indicating the present position of each.

The main idea in presenting this paper is to place before this gathering of agriculturists the main insect problems connected with paddy in South India and invite criticisms and suggestions from others who may be carrying on work on similar lines in other parts of India.

63. 'Kole cultivation' of paddy in Cochin State with special reference to insect pests.

C. S. VENKATASUBBAN.

'Kole cultivation' is a system of growing paddy, peculiar to Cochin State and some parts of British Malabar. The lands used for this purpose are very low-lying and situated along Backwater channels. They are highly inundated during the rainy months of June to November and are subject to the influence of tides for the rest of the year. Details are given of how this area is drained and made fit for producing a high-yielding crop of paddy every year, from February to June.

Observations on the Entomological aspect of the crop for the past seven years show that certain insects are particularly addicted to this crop. The two most common of these are the case worm, *Nymphula* sp. and the swarming caterpillar, *Spodoptera mauritia*, of which the latter is very severe and extremely partial to this crop. General habits of the pest and remedial measures practised, are recorded. A new pest, the Noctuid, *Cirphis micaceæ*, appeared for the first time in 1931 in a severe form. The interesting fact about this pest is, that instead of pupating in the soil as 'Cirphis' species are recorded to do, the caterpillars of this species were found to pupate in cocoons of silk, inside tubular structures of a number of paddy leaves, tied together.

The study of the insect pests of this crop as compared with other paddy crops illustrates the truth, that pest outbreaks are chiefly determined by environmental conditions.

64. The life-history of *Eublemma scitula* Rambr., a predator of the lac insect.

M. P. MISRA and S. N. GUPTA, Namkum.

The paper describes the life stages of the predator. There are six larval instars in the months July–September. The larva after coming out of the egg enters the lac encrustation by biting a hole into it, but after the second instar, the larva feeds on the lac encrustation and the lac insects from above and not by remaining inside the encrustation. To protect itself, it spins a protecting cover of silk interspersed dorsally with remains of the lac insect and the encrustation. The protecting cover is held in position by the upturned anal legs, and the cover increases with the size of the larva. Before pupation, the protecting cover is turned by the larva into a complete pupation-case by spinning a thin sheet of silk below it in continuation with the protecting cover. At pupation the front side of the pupation-case ruptures and the opening is lined by the larva with a thin lining of silk. The adult emerges by breaking open this lining. The larva in addition to the lac encrustation and the lac insect also feeds on the parasites in the encrustation, but it is attacked by *E. amabilis* larva when they come in contact with each other.

The life-history period during these months (July–September) varies from 40–55 days.

65. Hymenopterous parasites of economic importance in S. India.

T. V. RAMAKRISHNA AYYAR and V. MARGABANDHU,
Coimbatore.

In view of the fact that mechanical methods of pest control, such as the use of insecticides, spraying, fumigation, etc., have been in some cases found impracticable and uneconomical, on account of the prohibitive cost of the treatment and the temporary and palliative nature of the results obtained, during recent years a new method of controlling insect pests has taken the field. This method of control is known as the biological method of control, by means of which natural enemies are utilised for controlling insect pests of crops.

The utility of these parasites to man may well be seen in the case of such crop pests as *Nephantis serinopa*—the coconut palm caterpillar; the several paddy pests such as *Schoenobius incertellus*, *Spodoptera mauritia*, *Cirphis albistigma*, etc.; the sugarcane borer *Argyria sticticraspis*; the ragi borer *Sesamia inferens*; the Sannhemp caterpillar *Utetheisa pulchella*, and among the Coccids and host of others.

Varied are the nature and kind of parasitism, the habits of these parasites and the relationship between them and the host.

To give an idea as to the parasites that exist in the South Indian region a list of parasites, with their hosts and locality, is given in the paper. This shows how vast the field is and how there is plenty of scope for utilising the parasites in the control of the several crop pests.

The object of this paper is, therefore, (1) to show the richness of parasites or natural enemies found on several major crop pests in S. India, (2) how useful these parasites are to man in the control of some of the major crop pests of S. India, (3) the complexity of the problem in view of the wide and varied habits of the minute insects and the consequent careful study the problem requires before any venture is made in this direction, and (4) the vastness of the field; the great economic importance as well as the deep academic interest it stimulates.

66. Oviposition, longevity, number of broods and the alternative hosts of the chalcid *Brasema annulicardis* Cam., a parasite of the Lac Insect and *Bracon tachardiae* Cam.

S. N. GUPTA and P. S. NEGI, Namkum.

The chalcid *B. annulicardis* is primarily an endoparasite of the Lac Insect, and an ectoparasite of the full-fed larva, pre-pupa and early pupa of *B. tachardiae*, a parasite *E. amabilis* larva. The chalcid oviposits on the stages of *B. tachardiae* only if covered with a cocoon. Under natural conditions it seems to spot these stages, with the sense seated in the antennæ and ovipositor, either under the Eublemma domes or lac incrustation. Superparasitism and laying of more than one egg by the same female on the same host occurs when *B. tachardiae* is the host, but in either case only one of the eggs develops to the adult. The chalcid first deposits the egg on the host and paralyses it afterwards by several stings of the oviposition. Oviposition and longevity is described. The chalcid seems to have 14 theoretical generations in a year based on monthly life cycles. But if the pre-oviposition and the search period is considered to be equal to a third of the yearly average longevity, and

the total of this and the yearly average life-history divided into 365 days of the year, the chalcid would seem to have only 9 generations in a year. The known and suspected alternative hosts of the chalcid are :— (1) *Coccophagus tschirchii*, a parasite of the Lac Insect; (2) *Machærota planitiae*, a pest of the plum plant; (3) *Holcocera pulvereæ*, a predator of the Lac Insect; (4) *Tachardicephagus tachardice*, a parasite of the Lac Insect; (5) *Apanteles tachardice*, a parasite of the larva of *Holcocera pulvereæ*.

67. Ecological studies of the distribution of Pink-Bollworm in the Punjab.

M. HAROON KHAN, Lyallpur.

A correlation between the fecundity of Pink-Bollworm and incidence of attack has been established. At Rohtak, where this insect is a serious pest, average individual oviposition, when the attack starts, ranges from 13 in July to 49 in August; at Sialkot, where the attack is mild, oviposition ranges from 7 to 40; and at Lyallpur, where Pink-Bollworm is not a pest, oviposition ranges from 2 to 11 only. Climate, therefore, affects the procreative function and is responsible for the distribution of this pest.

Maximum oviposition occurs at 25°C., but it is interesting to note that at the same temperatures the number of eggs laid per individual is much higher at Rohtak than at Lyallpur. This supports the hypothesis that the temperature, to which pupæ of the Lepidoptera are subjected, influences the egg-laying capacity of the adults. To test this hypothesis pupæ were exposed to various temperatures and there is reason to believe that moths emerging from pupæ kept at high temperatures such as 33°C. lay fewer eggs than those emerging from lower temperatures such as 27°C.

68. The Mekran coast—possibly the area of origin of the great locust invasion of 1926 in Sindh.

Y. RAMCHANDRA RAO, Quetta.

The Locust invasion of 1926 in Sindh was an event of high importance in regard to Indian Agriculture, since it was the starting point of the serious infestation that lasted till 1931, but its origin remains a mystery owing to lack of definite data regarding locust movements in India prior to September, 1926.

A study of locust movements in Baluchistan during 1927–31 shows that they take definite directions at different seasons. In spring, the movement is from west to east, over-wintered locusts flying from Persian borders into Mekran, Chagai, and North Baluchistan and laying eggs. The new generation produced in these regions ultimately enters the monsoon areas of Lasbela, Sindh, and Punjab during summer. In autumn, there is a reverse movement from Sindh into the winter-rainfall tracts of Baluchistan and Persia, where the locusts probably over-winter until spring.

While locusts were non-existent in most areas in India during 1920–25, in Mekran, swarms of hoppers occurred in Dasht in May, 1923, as also hoppers and fliers in Kulanch in June, 1926. Lasbela records show that swarms appeared at Sheh-Lakhra in August, 1926. By September, extensive oviposition had occurred in Lasbela and in Karachi district following abnormal rainfall. It is surmised that it was the June swarms of Kulanch that had moved eastwards into Lasbela and Sindh and started the great Indian infestation of 1926.

Along the Mekran Coast, there are large stretches of sandy soil covered with evergreen scrub where locusts are always present and multiply when favourable rainfall occurs. In January, 1926, extra-

ordinarily heavy rain had fallen all over the Mekran Coast and gave rise, probably, to the Kulanch fliers of June, 1926.

ANIMAL NUTRITION.

69. Substitutes for stall feeding of dairy cattle.

C. MAYA DASS and ALAM SINGH, Cawnpore.

The high cost of production of milk being one of the direct results of stall feeding of dairy cattle, a preliminary investigation was started in 1929-30 and is still in progress. The investigation shows that the almost entire substitution of feeding cattle in standing crop of a mixture of three parts cereal by weight to one part legume or brassica is not only cheaper but productive of better results so far as milk yield is concerned than purely stall feeding in the ordinary course. The paper gives tables showing the results of investigations.

IMPLEMENTS.

70. The 'Sukhada' implement and its suitability for the management of clay soils for higher crop production.

B. N. SARKAR, Bihar.

The difficulties experienced in India in the management of soils in general and clay soils in particular with the existing indigenous and western implements are that the former are very slow and often unsuitable for purposes of special cultivation such as hoeing and earthing up of crops. Western implements on the other hand, though very efficient, are frequently unsuitable. Clay soils tend to form clods if ploughed with mould board ploughs. They are generally unsuitable for obtaining a good seed bed for rabi sowing. 'Cultivators' are very good for all purposes including hoeing of crops but they are generally unsuitable for Indian cultivators on grounds of cost and complexity of design.

In designing implements for Indian cultivation the following points have to be considered :—

1. The cultivator is too poor to afford a variety of implements.
2. The implement must be light and easily portable so that a cultivator can carry it on his shoulder from one place to another of his scattered holding.
3. The use of bolts and nuts are foreign to Indian cultivators and should be avoided.
4. The implement should be simple enough to be repaired in the village.

The writer with the help of his wife has recently designed the 'Sukhada' outfit for the country plough which satisfies all the above considerations. 'Sukhada' outfit, type B, provides a three-tined cultivator, a furrower and a broad share as interchangeable attachments to the ordinary country plough. There is not a single bolt and nut in this type. The whole outfit can not only be repaired but can be easily made in the village, while the work done by it is in no way inferior to that done by more costly implements. The hoe costs Rs. 3, the furrower Rs. 2-4, and the broad-share Re. 1 to make. 'Sukhada' outfit type A is a heavier model and suitable for very clayey soils. It costs Rs. 14 to make.

The discovery of the principle of providing different implements as attachments to the ordinary country plough has enabled the designer to do away with all costly frame work, poles, handles, etc., thus reducing the cost to the minimum; while the steadiness and ease of handling the

country plough have contributed largely to the efficiency of the work done by these attachments.

MISCELLANEOUS.

71. Canal irrigation and weed distribution.

T. S. SABNIS, and D. N. SINGH, Cawnpore.

1. Weeds brought in by the canal water are considerable.
2. Eradication by weeding after weeds are once established is both expensive and ineffective.
3. Distribution of different weeds brought in by the canal water was studied by the Quadrat method.
4. Weeds belong to a number of families and vary in their habits of growth.
5. Yield of agricultural crops is greatly affected by weeds.
6. Filters were found very effective as preventive control measures.

72. Cold storage of mangoes.

B. N. BANERJEE and G. RAMAKRISHNA RAO, Bangalore.

Experiments to preserve mangoes in cold store have been continued. It has been found that the correct regulation of temperature and humidity is very important. It is useless to hope to preserve any mango that has suffered any damage (mechanical or otherwise) in plucking, transport, or in storage. The skin of the fruit has also to be carefully protected from any injury, as on ripening they serve as nucleus of rotting. This requires careful attention to humidity at about 75% as also the process of cooling adopted. A mature green mango carefully plucked and kept in cold store at 5° to 10°C. at 80% humidity ripens in 3 to 5 weeks and then cooled to 0°C. can be used as fresh fruit for another 10 to 15 days. After that it is better to preserve in syrup or otherwise.

Mango pulp kept in cold store in syrup acidified with vinegar, tartaric acid or citric acid preserves the vitamins better and longer: kept in syrup with SO₂ (·04%) they taste best, and can be preserved for months.

73. Studies on the symbiotic action of yeasts and lactic acid organisms.

N. V. JOSHI, Pusa.

Pure cultures of lactic acid organisms isolated from *Dahi* (Indian milk curd) were found to die within a fortnight unless transfers were successively made. This auto sterilisation of the cultures was not found to be due to acidity developed in the culture.

A torula found associated with these organisms in *Dahi* counteracted this tendency and the mixed cultures were found to survive over six months.

A yeast of the *Cerevisia* type was also found to possess this property.

Extracts of the yeasts and the torula also prolonged the life of the pure cultures of lactic organisms for two to three weeks.

It is considered that some vitamin or enzyme secreted by the yeast and the torula is responsible for counteracting the effects of the by-products of the lactic acid organisms which become inactive in pure cultures and enable the cultures of lactic acid organisms to survive for long periods.

This property of the yeast and the torula can be utilised in sending live cultures of lactic organisms to a long distance by post.

Section of Mathematics and Physics.

*President :—*DR. A. L. NARAYAN, M.A., D.Sc., F.I.P.

Presidential Address.

RECENT DEVELOPMENTS IN SPECTROSCOPY.

LADIES AND GENTLEMEN,

Before I take the Chair, I wish to express my sincere thanks to you and the Council of the Congress for the honour you have done me in electing me President for the Mathematics and Physics section of the Science Congress this year.

I take it that it was in recognition of a few contributions I have been able to make during the past few years. I may at once say that it would not have been possible for me to accomplish what little I have achieved if I had not the assistance of a few enthusiastic research workers, prominent among them being K. R. Rao, I. R. Rao, and A. S. Rao. Year after year the general convention seems to be that the President should deal in his address with some subjects in which he is interested and should give a generalised statement of his own researches. Just two years ago, Prof. Venkatesachar occupied the Chair and delivered one of the most interesting presidential addresses on Series Spectra and Hyperfine Structure of Spectral lines which is also my line of work.

I have, therefore, chosen 'Recent Developments in Spectroscopy' as the subject of my address. In the brief space at my disposal as it is not possible to treat the subject in a comprehensive manner, I propose to summarise my scattered ideas on principally recent developments, which have added much to our understanding of 'Matter and Radiation'. The last few years of the history of Spectroscopy furnish a striking illustration, first of the enormous output of work, and second, of the power of experimental and theoretical methods combined for predicting new phenomena.

ATOMIC SPECTRA AND VECTOR COUPLING.

The systematisation of spectra, due to Hund, starts chiefly from the work of Russel and Saunders on the spectra of the alkaline earths. Without doubt the greatest progress in the interpretation of complex spectra is based on the suggestions of Russel and Saunders; of Pauli and Heisenberg.¹ The great success of these new ideas is that they not only predict the optical terms of the spectra of a shell but are also able to show the necessity for the existence of shells and thus leads to a

complete theory of the Periodic system. Discovering a series of the so-called *pp'* groups, Russel and Saunders arrived at the conclusion that, when we consider the characteristic emission by an atom, we should take the effect not only of the one labelled, 'series electron', but that of all the outer electrons. It is not the orbital moment of only a single electron that should be quantised but the quantised resultant sum of the orbital momenta of all the individual electrons should be considered. This type of coupling of the individual '*ls*' of all the electrons is usually known as 'Russel-Saunders' or the normal type of coupling and is represented thus,

$$(s_1 s_2 \dots) (l_1 l_2 \dots) = (sl) = j.$$

This implies that the interaction energy of the spin moment '*s*₁' of one electron and *its own* orbital moment '*l*₁' is much less than the interaction energy between the spin momenta *s*₁*s*₂ of different electrons. In a two-electron system, it is as if the influence of the second electron on the first is equivalent to that of a strong magnetic field. The existence of such strong interaction energy between the spin momenta, strange though it seems to be from the ordinary viewpoint of the vectorial model of the atom, is, in reality, only a manifestation of the phenomenon of 'resonance' discovered by Heisenberg and Dirac.

With the adoption of this idea, the vectorial method of treatment has proved indeed to be most fruitful in the interpretation of spectra. The spectra of the lighter elements and generally those which occupy the right sub-group of the periodic table, do exhibit this normal type of coupling. Interval and intensity rules, deduced on the basis of this scheme, have approximately been verified in some of these cases. It must not, however, be concluded that this simple scheme of Russel and Saunders is universally applicable. There have already been found numerous instances of spectra in which a definite departure is noticed. It is, unfortunately, such spectra in which these departures are most marked that are most difficult to tackle. Notable examples of these are the spectra of the heavier elements like Thallium, Lead, Bismuth. Thallium IV—a platinum-like spectrum having a configuration of ten '*d*' electrons—exhibits a typical breaking off from the normal scheme. A detailed study of such spectra and of the anomalies that they present, is a subject of far-reaching importance and demands the careful work of several investigators.

In contradistinction to this normal '*ls*' scheme which properly should be termed as one limiting type, there is a second, the other extreme type of coupling which is designated as the (*jj*) coupling and represented as

$$(s_1 l_1) (s_2 l_2) \dots = j_1 j_2 \dots = j.$$

This occurs when the interaction energy between the spins

is not strong enough to break down the coupling between the spin and the orbital momenta of the individual electron and corresponds, therefore, to the effect of a weak field. Between these two extreme types, there may be various other intermediate possibilities, analogous to the case of fields of intermediate strength. But, whatever the type of coupling, we arrive at precisely the same number of different energy levels, characteristic of any atom, with the same values of j for these states.

It is extremely difficult to make definite conclusions about the nature of the coupling exhibited in any case, except where one of the two 'pure' cases—either the ' ls ' or the ' jj '—holds good. There are generally three criteria available for such a study of the vector coupling in complex spectra; namely (1) the relative magnitude of the energy levels, (2) the intensities of the combination lines, (3) the behaviour of the lines in a magnetic field. Of these, at the present stage of development of experimental technique, a study by the two latter methods is beset with great difficulties. To any ambitious investigator a study of the intensities of spectral lines under different conditions offers certainly a very wide field for research. The deductions made from the third criterion of comparison of the relative energy levels are usually very reliable as they can be based on the definite experimental classification of the spectral lines; this criterion is often the first to indicate a breaking off from the normal coupling. It is found even in relatively very simple cases of spectra such as those of Ge I, As II, Se III, that there is an interpenetration of the different levels arising from a given electron configuration and that the intervals of even the deepest terms show marked abnormalities. It may not be out of place here to mention that during the last few years rapid progress has been made in the spectral classification of these elements by K. R. Rao and A. S. Rao and myself, and we have made an exhaustive analysis of these spectra in successive stages of ionisation and published numerous papers.²

A great deal of interest centres round the determination of the characteristic energy levels of various spectra. It was the discovery of these levels or so-called 'terms' in Hydrogen and other simple elements that paved the way to the fundamental ideas of Bohr; it was the analysis of the more complex spectra like those of Cr and Mn that led to a far-reaching extension of these ideas; it was the classification of the spectra of He and of the alkaline earths which contributed substantially towards a general systematisation of our knowledge of the mechanics of the atom; and it is not difficult to foresee that, one day, the success of the patient endeavours of some investigator in unravelling the extremely complicated structure of the spectra of the rare earths would be another landmark in the history of the development of this most fascinating field of spectroscopy.

I have confined myself in the above discussion to a method of treatment of spectra which depends essentially on a vectorial model of the atom. In spite of its inherent defects, and in spite of the more recent and exact wave mechanical treatment, the vectorial method is usually retained on account of its simplicity and the ease of visualisation.

VACUUM SPECTROSCOPY.

A great step forward in unravelling spectra was taken by Millikan and Bowen³ when, in 1924, as a result of their work on series relations between spectra of stripped atoms, they made an important discovery that the so-called 'regular' and 'irregular' doublet laws of X-ray spectra are applicable also in the optical region, while different explanations have hitherto been given for them in the two fields. In the X-ray region the doublets are explained as due to different shapes of orbits involving differences in shielding and relativity correction, while in the optical region they are due to the differences in the orientation of series electron orbits with respect to the atomic residue. This discovery opened up a new and unexpected difficulty in our understanding the origin of the X-ray doublets, which then were believed, according to Sommerfeld, to arise from a relativistic change in the mass of the electron. The difficulty remained unsolved till, on the basis of Goudsmit's⁴ spinning electron, Heisenberg and Jordan and later Darwin⁵ obtained exactly the same formula as Sommerfeld did, on the assumption of the relativistic mass. The mechanism which gives rise to these doublets lies therefore in the magnetic interaction between the spin moment of the electron and its orbital motion; the doublets are no longer 'relativistic' but may properly be called 'magnetic' or 'spin' doublets. This assumption constitutes a fundamental advance in our understanding of the nature of the ultimate thing with which Physics deals, viz. the electron.

Apart from the theoretical importance, the discovery of Millikan and Bowen gave a fresh impetus to the study of the spectra of the elements in the very extreme ultra-violet. It placed in the hands of the practical spectroscopist a powerful weapon which he may wield with ease and confidence in attacking even the most complicated spectrum with great success. The discovery itself was due, indeed, mainly to the development of the technique of Vacuum Spectroscopy. In spite of years of work in experimental spectroscopy, the need for more work is still as great as ever; the characteristic spectra of many elements in the extreme ultra-violet beyond the quartz and Schumann regions are yet unexplored. It is gratifying to note that at Waltair, K. R. Rao has taken up a systematic study of the spectra of rare earths in this region. Vacuum spectroscopy

had made but just a beginning with the work of Millikan and Bowen. Its technique demands a great skill on the part of the investigator. The construction of the instrument itself for photographing this region of very short waves is extremely simple; the essential difficulty arises in producing the necessary high vacuum in a chamber of capacity as high as a hundred thousand c.cms.

During the last three years, particularly through the work of Siegbahn and his collaborators at Upsala, an important modification has been made in the design of the spectrograph, which made it particularly suitable for photographing the regions of wavelength even smaller than 100A. The grating, instead of being mounted at nearly normal incidence as in the usual instrument, is mounted at nearly grazing incidence, thereby enormously increasing its reflecting power for extremely short waves.

Turning now to the sources that can be employed in vacuum spectroscopy, it may be remarked that the hot spark that is commonly used, is no doubt very rich in emission lines of atoms from which many or all of the outer electrons are completely knocked out. But, as a method of excitation of spectra, the discharge tube seems to afford a much wider range of ionisation. Figures I (a) and (b) are the photographs of the Giessler tube spectrum of As, recently photographed by Rao in the course of his analysis of the first spark spectrum. All the arc lines and lines of third and higher stages are completely suppressed and the first spark lines have all come out very prominently. I must here refer you in particular to the method of the hollow cathode discharge, in a rare gas atmosphere, designed and very widely used by Paschen and his collaborators. The method is particularly suitable for the investigation of the spectra of atoms in a low stage of ionisation. For the excitation of the spectrum in this source, occurs a so-called collision of the second kind between the rare gas atoms in a metastable or ionised state and the metallic atoms and is, therefore, limited by the energy of ionisation of the rare gas atom. This source gives beautifully sharp lines and lends itself specially for the investigation of the hyperfine structure of spectral lines.

Quite recently, in the course of their experiments on the spectrum of Arsenic by the hollow cathode discharge, K. R. Rao and T. S. Badami⁶ found that the Lyman series of hydrogen came out with remarkable strength down to the fifteenth number, the important feature of the series being the curious intensity anomalies exhibited by the numbers (Fig. II). The suggestion is made by Rao that the phenomenon is caused by a transfer of energy by collisions of the second kind, between the ionised atoms of Arsenic in the metastable state and the atoms of Hydrogen. There is in this evidence of a new type of impact. If it should turn out that this type of collision

really occurs, it should have an important bearing on many discharge tube phenomena.

HYPERFINE STRUCTURE.

While working on the spectra of various elements, it has been found by several investigators from time to time that the lines attributed to electron spin are themselves composed of several components and that these fine structure separations are much smaller than the splitting due to the couplings between the extra nuclear electrons. This H.F.S. is explained by attributing to the nucleus of an atom a resultant spin momentum and therefore a magnetic moment, which is capable of interacting with the outer electrons. Fine structure observed in spectral lines might therefore be due to (a) the action of the nucleus of the atom, (b) its electron configuration, and (c) its isotopic features. During the past few years much has been written on the theoretical interpretation of these *hfs*. It does not therefore appear necessary to give an account of the theoretical details here. The theory predicts that the fine structure separations follow the interval rule accurately. Hargreaves⁷ starting from the hypothesis of the nuclear spin, applied the methods of new quantum mechanics to the problem and derived intensity formulæ applicable in the general case. Hill,⁸ Zeeman, Back, and Goudsmit⁹ have similarly obtained intensity formulæ which are found to hold exactly in the case of several *hfs*. According to the Vector coupling scheme it will be expected that an unpaired 's' electron is most penetrating. At the time of its deepest penetration there occurs the strongest coupling between electron spin and nuclear spin which results in wide fine structure separations. Therefore in atomic systems where fine structure appears, wide fine structure separation occurs in terms associated with a deeply penetrating 's' electron. These separations are widest in the heavier elements of the periodic table.

If the *hfs* are to be attributed to the nucleus, then the spectra from a neutral atom or singly ionised or doubly ionised atom should all reveal the same spin moment for the nucleus. This has not yet been verified even in a few cases. Comparatively little work has so far been done on H.F.S. Even in the case of the few spectra that have been investigated, there seem to be considerable differences between the results of different investigators. The deviations in some cases are so large that it is difficult to interpret them as such. From the observational material available, it is difficult to say whether this divergence is due to the inadequacy of the theory or the extreme difficulty of experimentation. There is no doubt that for work in this field, greatest possible accuracy of observation and most careful judgment and discretion in the identification and measurement of satellites are necessary.

During the past two years, in the spectroscopic section of the Observatory at Kodaikanal, Rao and myself have made a systematic study of the H.F.S. of the arc lines of Thallium and Indium and of the spark lines of Arsenic and Bromine. Fine structure patterns are not generally completely resolved owing to the effect of the electric fields and pressures in broadening spectral lines. For studying the fine structure of the arc lines of Thallium and Indium we used a specially constructed vacuum arc of 2 per cent. amalgam of Mercury and Thallium and Mercury and Indium. The cathode was throughout kept cooled by surrounding with running water. The advantages of this type of source have been described by Venkatesachar in several papers. Owing to the extremely low partial pressure of Thallium or Indium vapour, the lines were found to be extremely sharp and without self-reversal. This vacuum arc was first constructed for precision wavelength measurements of the resonance lines of Thallium, with a view to identify the lines of this element in the solar spectrum. The evidence for the presence of Thallium wavelengths in the solar spectrum rests on two lines 5351 and 3775 ($6P-7S$) of solar intensities -3 and -2 respectively. In view of the fact that both these lines coincide with very faint solar lines and the line 5351 does not appear to be strengthened in the spot spectrum while generally all the arc lines are considerably enhanced, it would appear that the evidence for the identification of this element in the sun is very meagre. The fine structure was studied by using a quartz Lummer plate ($8\text{ mm.} \times 200\text{ mm.}$) and a glass Lummer plate ($4.8 \times 135\text{ mm.}$), and fused silica plate etalons of 2 and 2.5 mm. thickness. The fine structure of the arc lines of Thallium has previously been studied by Rewark and Chenault,¹⁰ Back¹¹ and Wali Mohammad,¹² and more recently McLennan and Crawford,¹³ Schuler and Keyston,¹⁴ Jackson, and by Rao and myself.¹⁵ Schuler and Keyston and Rao and myself found an isotope displacement of about 0.05 cm^{-1} in the case of 5351 while McLennan and Crawford discovered no trace of isotope shift.

McLennan and Crawford and Schuler and Keyston found the line 3776 ($6P-7S$) to be a triplet and proposed a term scheme based on these measures. Though no isotope shift was found in this case, we pointed out that the line was found to have five components. At that time the component $-0.54A$ was not found on our photographs. In the plates subsequently obtained this component was clearly shown as will be seen from the microphotometric curves (Fig. III). From these fine structure measurements it was pointed out by us¹⁶ that the complex structure could be explained by supposing that $^2P_{\frac{3}{2}}$ term like $^2P_{\frac{3}{2}}$ term shows an isotope shift of about 0.05 cm^{-1} . The structure now given removes the anomaly noted by Schuler and Keyston in the isotope displacement of $^2P_{\frac{3}{2}}$ term. At the same time the structure observed by us still contains a com-

ponent $-117A$ which does not find a place in the scheme. This satellite has been observed previously only by Wali Mohammad. Recently Jackson¹⁷ also made more careful observations on the structure of this line and revised his former results and proposed a level scheme which is substantially the same as ours. Only the satellite $-117A$ is not found in his measurements. The level scheme and line structure are shown in Fig. IV.

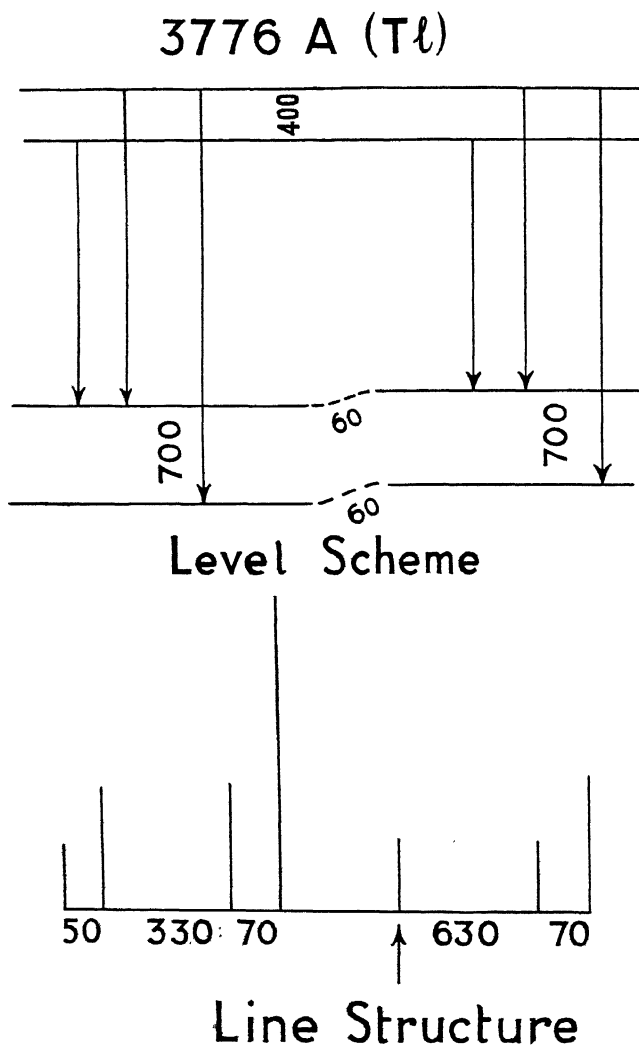


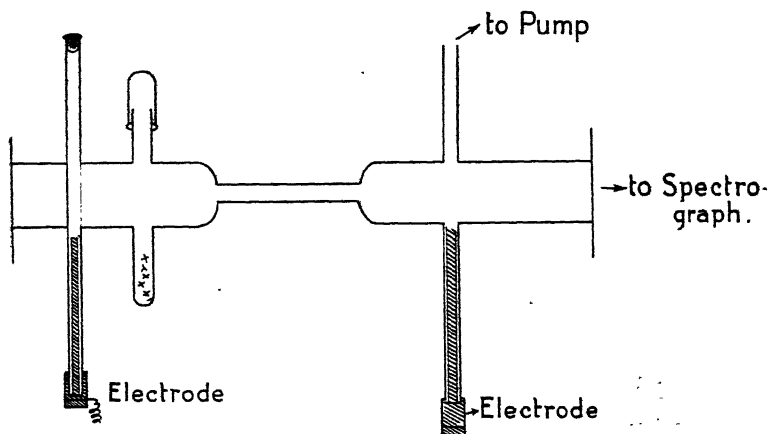
FIG. IV.

The fine structure measurements for 3776 are given in the following table and includes for the sake of comparison the data of McLennan and Crawford, Schuler and Keyston, and Jackson :—

		in \AA	in cm^{-1}	Jackson	McLennan and Crawford and Schuler and Keyston
3776	..	0.000	0.00	0.000	0.000
(6P—7S)	..	—0.007	0.05	—0.007
		—0.054	0.38	—0.056
		—0.064	0.45	—0.065	—0.058
		—0.117	0.82
		—0.154	1.08	—0.157
		—0.165	1.15	—0.165	—0.159

As we have pointed out recently in a note in *Current Science* it is very remarkable that slight variations in the excitation result in marked changes in the relative intensities of the components. Pressure conditions seem to be very important in the excitation and therefore in the intensity relationships of the fine structure components. A similar fact was noticed by Schuler and Keyston¹⁸ and Subbaraya and Iyengar¹⁹ in the case of Mercury. It is nevertheless difficult to see how these slight variations in the conditions of excitation can influence the interaction between the nucleus and the electron shell.

While we were photographing the discharge tube spectrum of Arsenic for the gross multiplet analysis of As II it was found that certain prominent lines which should enter into the classification possessed a fine structure. A special investigation of the fine structure of the spark lines of Arsenic was therefore planned. In our experiments on the structure of the first spark lines of Arsenic, a Pyrex Geissler tube with capillary portion 10 cm. long and 1.5 mm. diameter with thick nickel electrodes was used (Fig. V). A quantity of pure Arsenic



DISCHARGE TUBE

FIG. V.

is contained in the side vessel which was heated occasionally by passing a small current through the heating coil. In our experiments on Bromine, a quantity of pure copper bromide or silver bromide was contained in the side vessel. The observations were made end on. The pressure of the vapour and the discharge could be so adjusted that the lines of the first spark spectrum were emitted strongly and with fair sharpness. The fine structure in these two cases was examined in the region $6300\text{\AA}-4000\text{\AA}$. Since these experiments were completed, Tolansky reported before the Royal Society²⁰ the results of his fine structure measurements on As II. It is to be noted that he based his studies on the unpublished data of K. R. Rao regarding the gross structure multiplet analysis. It is remarkable that the structures of some important lines differ markedly from our results. So far as I am aware the fine structure of the spark lines of As has not been studied by any other investigator. The $h\nu$ s observed by us are given in the following table which includes the values of Tolansky for comparison:—

λ	Classification	Structure in $\Delta\nu$ (authors)	Tolansky
6171	..	100, 0, 80, 115, 200?	118, 0, 76, 124, 201
6110	..	$1P_1-^3P_1$	Single
6023	..	309, 285, 200, 0	198, 120, 0
5686	..	190, 120, 0	..
5657	..	80, 0, 80, 420	0, 117, 195, 225
5651	..	$^3P_2-^3P_1$	0, 74, 112
5558	..	$^3P_2-^3D_3$	85, 0, 37, 112, 158
5498	..	$^3P_1-^3D_2$	Single
5331	..	$^3P_0-^3D_1$	0, 88, 119
5231	..	$^3P_2-^3P_2$	0, 197, 326
4985	..	$^3P_1-^3P_0$	0, 194, 311
4888	..	$^3P_1-^3P_1$	Single
4730	..	$^3P_0-^3P_1$	0, 139, 230
4708	..	$^3P_1-^3P_2$	Single
4371	..	$^1P_1-^1S_0$..
	..	$^3D_3-^3D_2$..
4336	..	0, 100, 260, 485, 635	0, 160, 274, 321
	..	$^3D_2-^3D_1$	0, 170, 290

The lines $\lambda\lambda 6110$, 5498, 4888, and 4708 have been described by Tolansky as single, showing no trace of structure even with $2\frac{1}{2}$ millions resolving power. Only, the two lines 6110 and 4708 showed distinct broadening towards the red. We photographed $\lambda 6110$ using Eastman hypersensitive panchromatic plates. It will be seen from the photographic reproduction and the microphotometric trace that in addition to the strong satellite $\Delta\nu$, there are two faint satellites. [Fig. VI (a) and (b).]

The line 5498 is found to have one satellite at $\Delta\nu=195$.

The wavelength of the other faint component has not been definitely fixed being very faint. (Fig. VII.)

$\lambda 4888$ shows a fairly strong satellite at $\Delta\nu=650$ while on some plates the second faint satellite at nearly $\Delta\nu=210$ is also shown. [Fig. VIII (a) and (b).]

The line $\lambda 4708$ is clearly resolved in our plates and shows the fine structure given in the above table. All the components seem to be equally strong.

The lines 5686 and 4371 have not been analysed by Tolansky. When analysed by the quartz Lummer plate, the line 5686 showed hazy wings on both sides. But when analysed by the glass Lummer plate the strong satellite at $\Delta\nu=420$ is distinctly seen. The photographic reproductions and the density curves show this satellite. [Fig. IX (a) and (b).] We examined the line 4371 ($4p' {}^3D_3 - 5p {}^3D_2$) by two Lummer plates and a fused silica plate etalon and found it to be a group of at least four components. The satellite 100 cm^{-1} is not yet fixed with certainty. The level scheme and line structure are given in Fig. X (a), (b), and (c). It would appear that the line fits into the graph at a ratio of lower to upper interval factor of $100 : 26$.

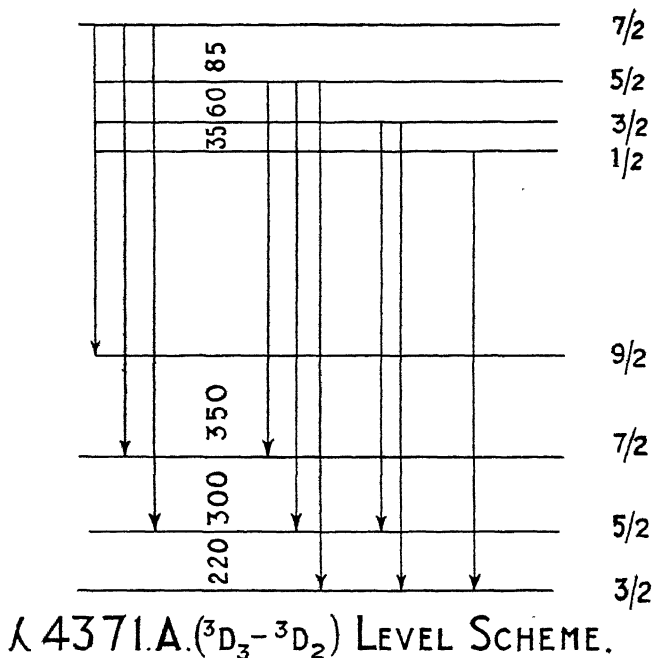
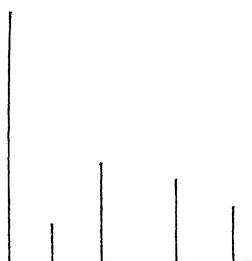
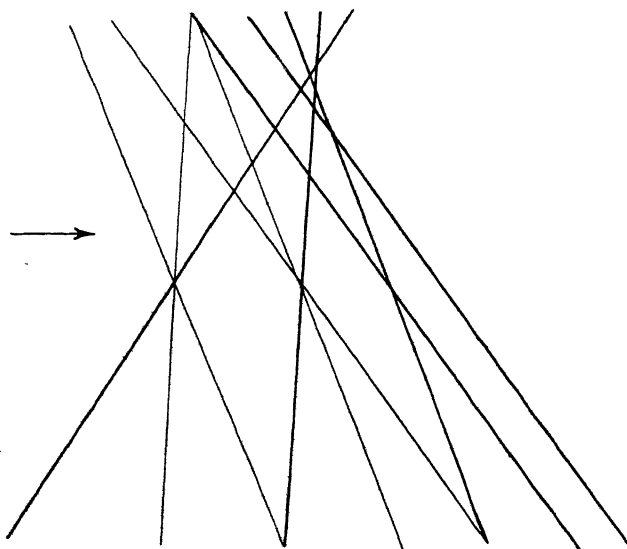


FIG. X (a).



λ 4371.A. (${}^3D_3 - {}^3D_2$) LINE STRUCTURE.

FIG. X (b).



λ 4371.A. (${}^3D_3 - {}^3D_2$) GRAPHICAL ANALYSIS.

FIG. X (c).

INTENSITIES OF SPECTRAL LINES.

The general theory of intensities of spectral lines is based on Bohr's correspondence principle of the probability of transitions from one stationary state of the atom to another. On the quantum theory of radiation specific relations exist between

the relative intensities of multiplet lines. In a series of papers published independently and practically concurrently, Sommerfeld, Ornstein, Russel, and Kronig²¹ have generalised the 'Sum Rule' making it applicable to all types of multiplets. Measurements of relative intensities are therefore important from the aspect of the quantum and the intra-atomic theories.

By far the most important work in this field is described by Ornstein and his collaborators in a series of papers which contain much useful and interesting information about the technique. It is only in recent years, owing to the perfection of the experimental technique of photometry, that attempts to obtain quantitative intensity measurements have been made. In the majority of cases, the intensities of lines in multiplets are found to conform to the Sum Rule, though in complex spectra with wide multiplets the deviations are considerable. An important application of this theory of multiplet intensities is by Russel, Adams, and Moore,²² to the calibration of Rowland's Scale of Intensities in the solar spectrum. The fundamental assumption underlying this work is that the intensities of lines in a multiplet are proportional to the corresponding intensities in laboratory emission spectra.

Owing to the difference in the conditions of excitation of the solar and the laboratory spectra, it is quite possible that this assumption is not quite justified. Attempts have recently been made by Woolley (Mt. Wilson Observatory) to obtain information on this point by measurement of the intensities of a few multiplets of Titanium and it is found that the divergence between the observed and theoretical values is very marked in many cases. In order to obtain more information on this point, I have recently carried out a series of experiments on a determination of the intensities of some important multiplets of Ni I in the solar and laboratory emission and absorption spectra. It will be remembered in this connection that Nickel contributes more than 600 lines in the solar spectrum and some of these are of the first order of intensity and lie in a region quite accessible to photography. Absorption spectrum was photographed in the laboratory by using an underwater spark between Nickel electrodes.

The solar and laboratory emission spectra were photographed in the 2nd order of the 13 feet plane grating spectrograph (ruled surface of the grating being 6 inches). In all these cases one-half of the plate was exposed to the solar or laboratory spectrum and the other to a 6-volt 24-watt tungsten lamp used as a source of calibration. For varying the intensity during calibration slit widths of 0.4, 0.6, 0.8, and 1.0 mm. were used, the time of exposure being the same. All the usual precautions have been taken in developing and fixing the plates. These plates were later microphotometered on a Cambridge photoelectric microphotometer. Without going into all the

experimental details and results obtained, I shall briefly refer to a few interesting cases. Fig. XI shows a microphotometric curve of the underwater absorption spectrum of Ni in the region 3550 - 3300 A.U. Two typical multiplets occurring in this spectral region are given below and the intensities are given on a homogeneous scale :—

		$a^3D - z^3F$		
		<i>Intensity in</i>		
λ		Underwater spectrum	Sun	Emission
3515.067	..	24	26	22
3458.468	..	21	17	23
3433.580	..	15	17	17
3414.780	..	30	33	24
3361.571	..	9	6	13
		$a^3D - z^3P^*$		
3524.54	..	43	53	39
3510.34	..	22	21	28
3492.97	..	34	26	33

* Only the diagonal lines are given here.

It will be seen from these and other multiplets thus far studied in the sun and the laboratory absorption, the stronger lines appear relatively much stronger, a fact which seems contrary to Woolley's conclusion that the weaker lines appear relatively stronger. A full account of these results will shortly be published in the Observatory Bulletin. It is important that further studies analogous to this should be conducted in other laboratories on gross and hyperfine multiplets.

A FEW IMPORTANT APPLICATIONS.

Based upon the large amount of accumulated spectroscopic material and the multiplet behaviour of spectral lines, many lines in the solar and stellar spectra have been identified in recent years. An important outcome of this is that 57 elements have now been identified in the sun with certainty. As a result of the spectral theories and the ionisation theory of M. N. Saha, a comprehensive study of the physical character of the sun and stars has been possible. Saha derived the following equation from his ionisation theory :—

$$\log \frac{x^2}{1-x^2} P = \frac{-5050I}{T} + \frac{5}{2} \log T - 6.5 - \log P_e,$$

where

x is the fractional number of ionised atoms in a given gas.

T is the absolute temperature.

I the ionisation potential.

P_e the electron pressure.

The equation shows that the percentage of ionisation increases with

- (1) increase of temperature,
- (2) decrease in pressure, and
- (3) decrease in the ionisation potential.

The brilliant and detailed success of Saha's ionisation theory in predicting the physical characteristics of stellar spectra is well known to those engaged in the interpretation of these spectra. An important outcome of this theory is that we now conceive the chromosphere consists of a gas supported by radiation pressure acting on the atoms and that the sun must be surrounded by an atmosphere of free electrons.

Among the problems of special interest in Astrophysics at the present time are those concerned with the mechanics of the chromosphere and the prominences on the limb of the sun. It has been suggested by Milne and others that the energy which supplies motion to the prominences is furnished by selective radiation pressure and this radiation pressure is sufficient to explain all the phenomena observed in the prominences. During the past three years extensive observations (visual and photographic) have been made at Kodaikanal to determine the size and shape of the prominences on the limb of the sun in K light of Ca^+ and $H\alpha$ light of H . Recently T. Royds,²³ the Director of the Observatory, made an extensive study of these photographs and found that the prominences of different types are all of the same kind and are practically identical in both these radiations, as will be clearly seen from Fig. XII. The importance of these observational facts is that the selective radiation pressure alone cannot be supposed to support the prominences above the chromosphere.

Three of the outstanding problems awaiting solution for a long time in the field of spectroscopy are:—

- (a) the origin of the famous green line 5577 in the spectrum of the auroral light and the spectrum of the moonless night sky;
- (b) the origin of certain unknown lines in the spectra of nebulae; and
- (c) the origin of some of the most prominent lines in the corona.

The green line $\lambda 5577$ which is the most prominent in the spectrum of the auroral light and which is characteristic of the spectrum of the night sky has been the subject of extensive research. In 1925 McLennan and Shrum put forward the view that auroral green line was identical with a sharply defined line which they observed in the spectrum of oxygen and that it is due to a transition between the low metastable energy states represented by 1D_2 and 1S_0 , and they succeeded in photographing the entire auroral spectrum including the green line

as a part of the spectrum of the discharge in a vacuum tube containing mixtures of helium and air, helium and oxygen, argon and oxygen, and neon and oxygen.

On moonless nights when the sky was cloudless, Meleannan using a spectrograph and photographic method and Lord Raleigh using a photoelectric cell found that the intensity of the auroral green line radiation from the night sky, gradually increased to a maximum value about an hour after midnight and then fell off again with lapse of time to sunrise. Recently K. R. Ramanathan made a few observations on the general spectrum of the night sky in India. From the few preliminary observations now available, he believes that the variation of intensity in the green line radiation between sunset and sunrise is quite the other way about. If it should turn out that the observations of Ramanathan are real, it should have an important bearing on the structure of the upper atmosphere in our latitudes. Extensive observations are therefore necessary in this direction. They can be undertaken by people possessing even a moderate equipment. A simple camera can be made with a wide slit, a green filter, and a good lens. Records of the intensity of the green line radiation at intervals of an hour can be obtained during the course of a single night. There is no doubt that the atmospheric conditions in India are on the average exceptionally good and the number of clear nights is greater than in many other countries. It seems to me that the ozone content of the upper atmosphere may have an important bearing on these radiations. It would therefore be particularly interesting if observations could be made on the night sky radiation and if estimates of the ozone content in the upper atmosphere are also made side by side during the same period.

In the nebulae are some prominent spectral lines which have never been observed in the laboratory. It was shown by Bowen²⁴ in 1927 that the eight strong nebular lines given in the following table—

Nebular Lines.

λ		Transition	Atomic System
7325	..	$^2D_{23} - ^2P_{12}$	O II
6584	..	$^3\bar{P}_2 - ^1D_2$	N II
6548	..	$^3\bar{P}_1 - ^1D_2$	N III
5007	..	$^3\bar{P}_2 - ^1D_2$	O III
4959	..	$^3\bar{P}_1 - ^1D_2$	O III
4363	..	$^1D - ^1S_0$	O III
3726	..	$^4\bar{S}_2 - ^2D_3$	O II
3729	..	$^4\bar{S}_2 - ^2D_5$	O II

originate in transitions from metastable states associated with atomic systems of O II, O III, and N II. It has been suggested that though under laboratory conditions the emission of radiation having these wavelengths seldom occurs, in a highly rarefied nebula, owing to the paucity of collisions of the second kind, these forbidden transitions can occur. Hopfield working in Paschen's laboratory obtained in the spectrum of oxygen under exceptionally heavy excitation the two nebular lines 6300 and 6364 A.U. These are the only nebular lines that have as yet been produced in the laboratory.

In the coronal spectrum are similarly found some of the most intense lines which have never been observed in the laboratory. The identification of most of these lines has not been possible so far. Hopfield believes that the red coronal line 6374.2 (In. 6) is identical with the unclassified oxygen-line 6374.29 and that this coincidence is strong evidence of the presence of oxygen in the solar corona. I hope that ere long it would be possible for some investigator not only to find a clue for the identification of these lines but to produce these spectral lines in the laboratory with a view to obtain information about the conditions under which these lines may be excited.

MOLECULAR SPECTRA AND RAMAN EFFECT.

After the advent of Bohr's theory, the spectroscopists engaged themselves exclusively to the study of atomic spectra for some time. But the extension of this theory to the explanation of molecular spectra by Schwarchild and others brought to light the importance of the latter to the understanding of molecular structure. The easy access to experiment of the visible and ultra-violet regions of the spectrum to which are confined the line spectra due to atoms, enabled a thorough investigation of the structure of the atom. In molecular spectra, though the electronic bands due to different molecules have been extensively studied, the rotation and vibration-rotation bands which respectively lie in the near and far infra-red regions have not been investigated at all, with the exception of those of a few gases like HCl, HBr, HI, H₂O, and CO.

Within the last decade, however, the investigations in the infra-red have received an impetus on account of their important bearing on theoretical physics. The diffraction grating in conjunction with the prism has enabled the workers in this field to attain a higher degree of dispersion, thus facilitating a resolution of the spectra formed in this region. Czerny's²⁵ work may be mentioned in this connection as an example of the important contribution of the study of molecular spectra to theoretical physics. His investigation of the pure rotation spectrum of HCl has convincingly proved the existence of half quanta in direct accord with the conclusions from Heisenberg's

Quantum Mechanics. We are still in the beginning of researches in the infra-red, and an extensive investigation in this region will give us much information regarding the dynamical state of molecules as the X-rays have given regarding their static condition.

The disabilities under which the physicist was working in the infra-red were removed by an entirely unexpected branch of physical research. The series of researches carried on at Calcutta by Raman and his collaborators on the classical scattering of light, which has thrown so much light on the structure of the molecules and their distribution in solids, liquids and gases, has resulted in the remarkable discovery of, what is nowadays known, as the Raman-effect.²⁶ It was theoretically forecasted by Smekal²⁷ in 1923, and by Kramers and Heisenberg²⁸ in 1925 in their classical paper on dispersion that a quantum of light incident on an electric oscillator cannot only be wholly absorbed or wholly scattered, but can also be partly absorbed resulting in a change of frequency of the other part which is scattered. This was experimentally achieved by Raman in 1928. The importance of this discovery to the understanding of molecular structure was realised by Raman himself. The improvement in the experimental technique of the Raman-effect made by R. W. Wood²⁹ has enabled many workers to investigate in this new field.

Briefly stated, the effect is simply this: when a light quantum of energy $h\nu$ is incident on a molecule in an energy state E_p , there is a certain probability of the molecule passing over to the energy state E_q with a change in the energy of the scattered quantum to $h\nu'$. The energy equation thus becomes:

$$E_p + h\nu = E_q + h\nu'.$$

Thus

$$h\nu - h\nu' = E_q - E_p$$

or

$$\delta\nu = \nu - \nu' = \frac{E_q - E_p}{h}.$$

Here $\delta\nu$ can be put in the form

$$\delta\nu = \frac{E_e - E'_{e'}}{h} + \frac{E'_n - E_{n'}}{h} + \frac{E_m - E'_{m'}}{h}$$

where E_e , E_n , E_m correspond to the initial, $E'_{e'}$, $E'_{n'}$, $E'_{m'}$ correspond to the final electronic, vibrational, and rotational energies respectively of the molecule

$$\delta\nu \begin{matrix} > \\ \geq \\ < \end{matrix} 0.$$

Thus the incident quantum may either lose or gain energy or may remain unchanged, entailing thereby a displacement of the spectral line corresponding to it either towards the red or the violet or no displacement at all corresponding to the

Rayleigh scattering. $\delta\nu$ represents the energy which a molecule is capable of absorbing or emitting and is therefore characteristic of it. This energy is well known to correspond (in general when $\delta\nu_e=0$) to the infra-red region of the spectrum, and hence by a study of monochromatic light scattered by any molecule the change in frequency given by the shift in the spectral line representing the incident quantum of light, gives us the infra-red characteristic frequency of the molecule. Thus by Raman's discovery we have a new method of investigating the infra-red by work in the visible region of the spectrum with all its advantages.

Apart from its contribution to a knowledge of the characteristic infra-red frequencies of molecules, there have been, within the last four years after the discovery of the Raman-effect, applications of it to entirely unexpected fields of research. Rasetti,³⁰ working on the Raman-effect in gases, found lines which indicate rotational transitions $m \rightarrow m-2$, $m \rightarrow m$, $m \rightarrow m+2$ in agreement with the well-known selection rules deduced from the quantum-mechanical theory of dispersion. He obtained, corresponding to vibrational transitions in O_2 , and N_2 , lines with no rotational structure, which show the very high statistical weight of the transition $m \rightarrow m$ in changes involving vibrational energy.

The next important application of the Raman-effect is to verify the Boltzmann's law of distribution in the different states of energy of molecules in a substance at a particular temperature. Raman and Krishnan in their early work³¹ found the possibility of verifying this law from a qualitative study of the intensity ratios of the Stokes's and anti-Stokes's Raman lines in carbontetra-chloride. The exact quantitative measurements were carried out by Ornstein and Rekveld.³² By considerations analogous to those adopted by Einstein in his treatment of Planck's law, it is shown that the ratio of the intensities I_s and I_{as} of the Stokes's and anti-Stokes's lines in the Raman-effect is given by

$$\frac{I_s}{I_{as}} = \frac{\nu - \nu_i}{\nu + \nu_i} e^{h\nu_i/kT}$$

where ν is the frequency of the quantum of energy incident on a gas containing molecules, some of which being in a lower state of energy are in a position to absorb, and others in a higher state, in a position to emit, the amount of energy $h\nu_i$. The above ratio is deduced from an assumption of the Boltzmann law for the distribution of molecules in the different states of energy in a substance. The intensity ratio determined experimentally by Ornstein and Rekveld is found to agree very well with the value calculated from a knowledge of ν , ν_i , h , k , and T . Thus we have in this a remarkable method of establishing the validity of Boltzmann's law.

Kohlrausch and Dadieu³³ on the one hand and Daure³⁴ on the other have systematically investigated the Raman-frequencies in a large number of aromatic and aliphatic organic compounds from the chemical standpoint. They have beautifully established the regularities in the Raman-spectra of homologous compounds. The former found the binding forces between the atoms constituting these molecules. The differences in the aliphatic and aromatic binding of the C-H, C-C, C-O, C-N, etc. groups have been very well confirmed. In fact, Raman-effect has been studied more from the chemical than from the physical standpoint.

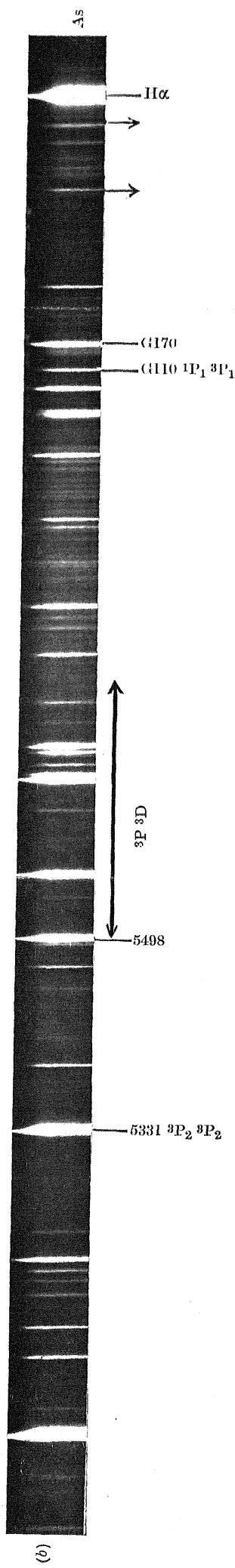
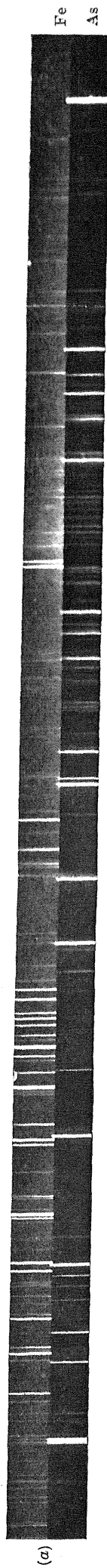
An entirely novel application of the Raman-effect has been made by Ramakrishna Rao³⁵ for the study of the nature of substances in a state of solution. By a measurement of the progressive changes in the intensity of the Raman lines corresponding to the undissociated HNO_3 molecules and the dissociated NO_3 ions in different concentration of nitric acid, he has ocularly demonstrated the phenomenon of electrolytic dissociation. He has obtained by this method relative values for the percentage dissociation of HNO_3 in solutions of varying concentration, which for the first time are independent of assumptions regarding the mobility of ions. The importance of this method of determination of electrolytic dissociation lies in that the intensities, being proportional to the number of molecules or ions, give a direct estimate of the degree of dissociation, which is not possible by other methods. In addition, the method suggested by Ramakrishna Rao is applicable to high concentrations and promises to give a clue as to the nature of concentrated solutions which still remains a puzzle to the physical chemist. He³⁶ has also applied the Raman-effect to the study of the composition of water and of its variation with temperature and addition of electrolytes. The explanation of the changes which have been proposed by Ramakrishna Rao bear a certain resemblance to those which have been offered for the existence of anomalies in the specific heats of the solutions of electrolytes.

There are many more important applications of the Raman-effect, but the most recent is that by Raman and Bagavantam³⁷ involving a novel idea of the nature of light itself. By studying the polarisation of the Rayleigh and Raman lines in gases (hydrogen so far examined), they come to the conclusion that the intensity anomalies obtained by them cannot be explained on the classical ideas of the quantum. They suggest the existence of spin in it and thus explain their results. If further experimental work on other gases confirms this, we will have to attribute spin to the quantum also. If this result is established beyond doubt, the existence of spin as a universal phenomenon will be the inevitable conclusion.

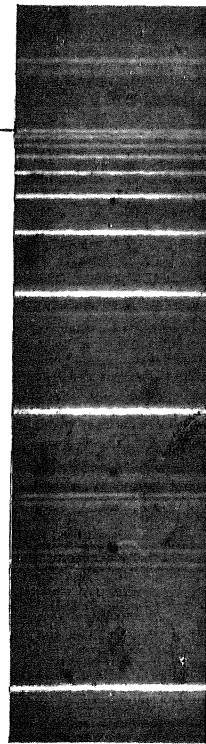
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AS DISCHARGE TUBE SPECTRUM. FIG. I (a), (b).



LYMAN SERIES OF HYDROGEN.



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Tl 3776

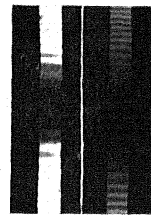
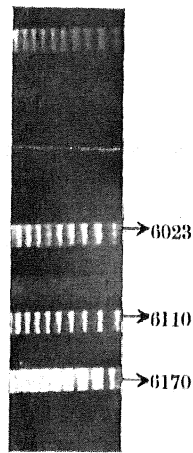


FIG. VI (a).



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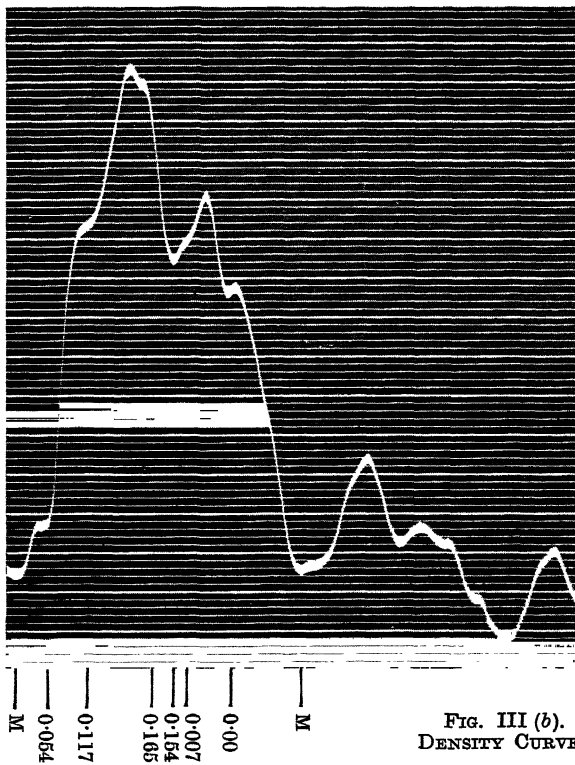


FIG. III (b).
DENSITY CURVE.



FIG. IX (a).

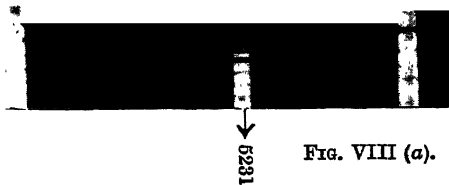
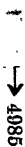
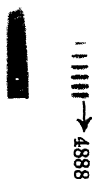


FIG. VIII (a).

Fig. VI (b).

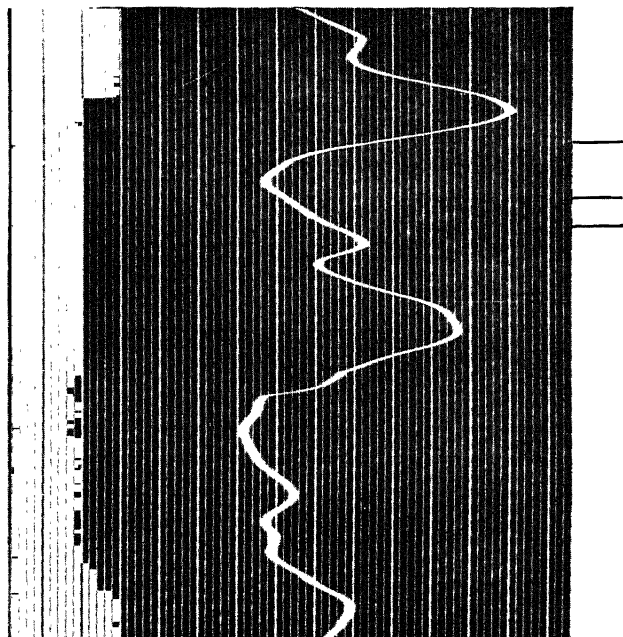
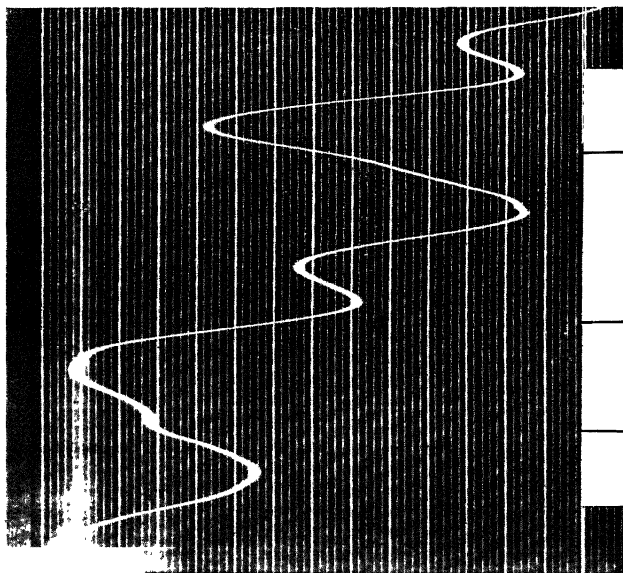


FIG. VII.

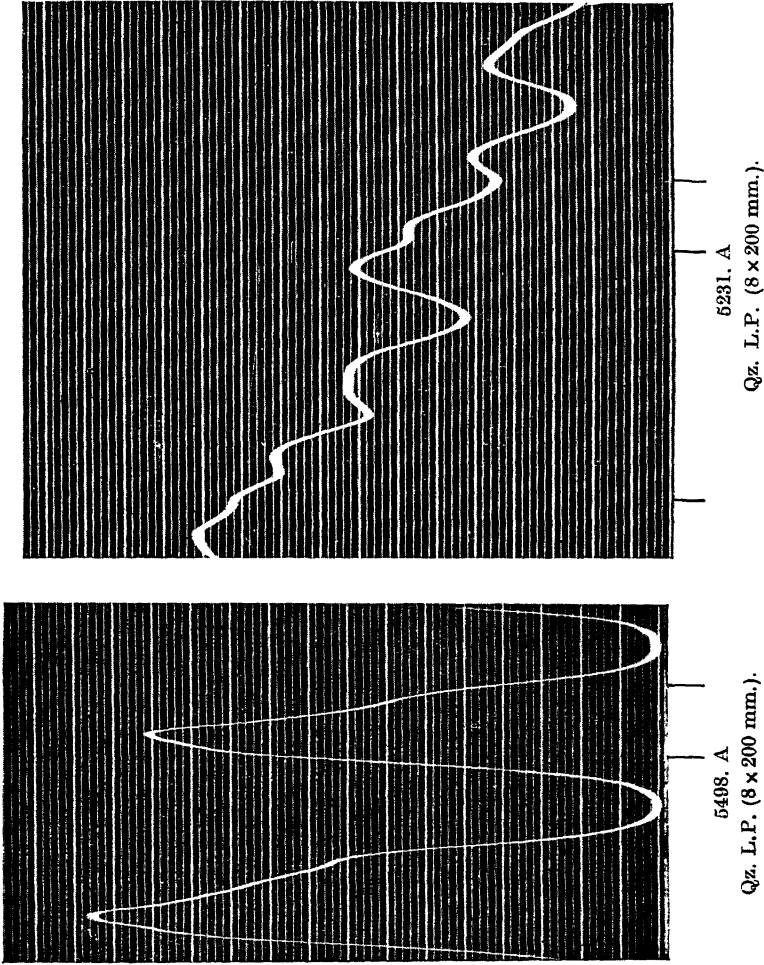


Fig. VIII (b).

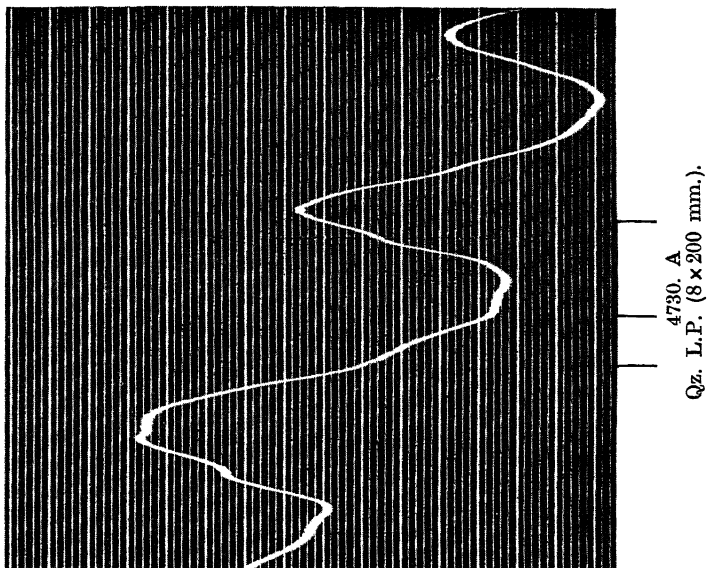
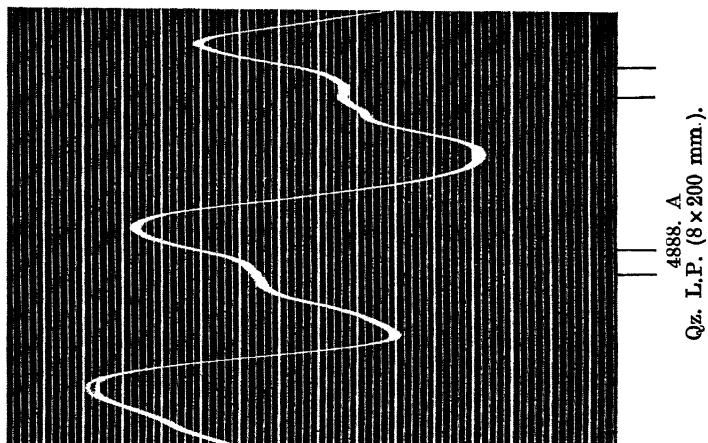
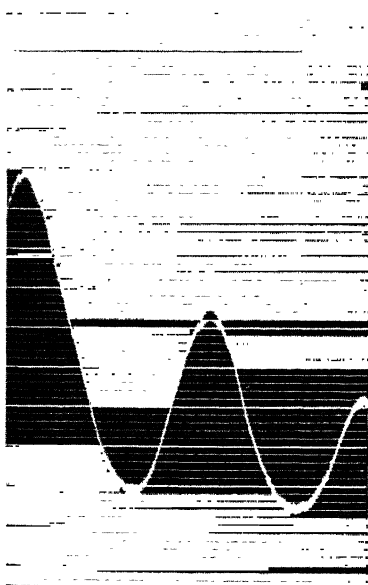
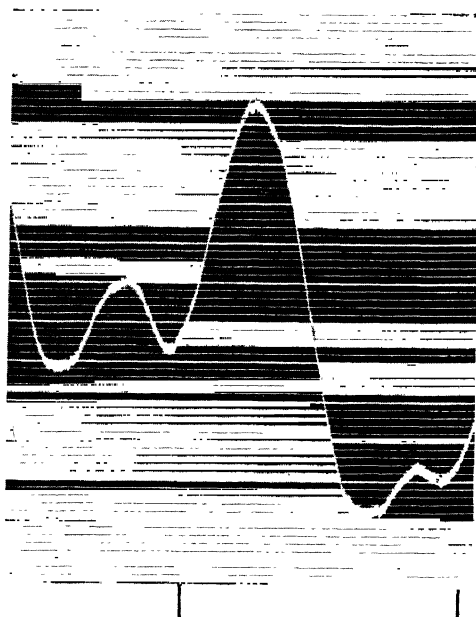


FIG. IX (b).

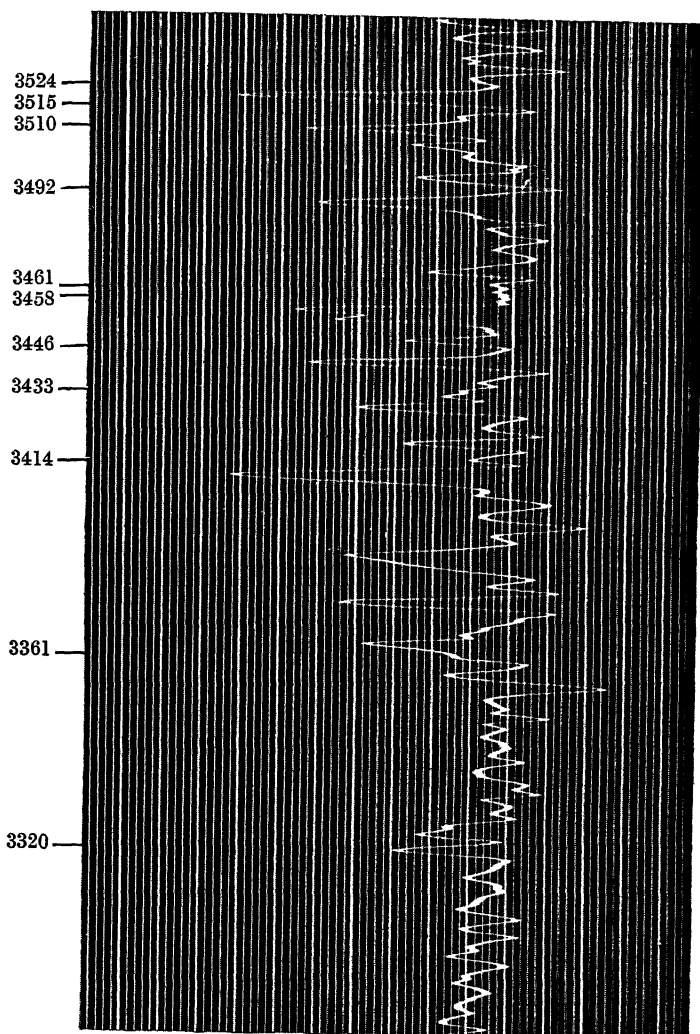


(a) Qz. L.P. (8×200 mm.).



5686. A

(b) Gl. L.P. (4.8×130 mm.).



Ni (U.W. ABSORPTION).
FIG. XI.

Fig. XII.

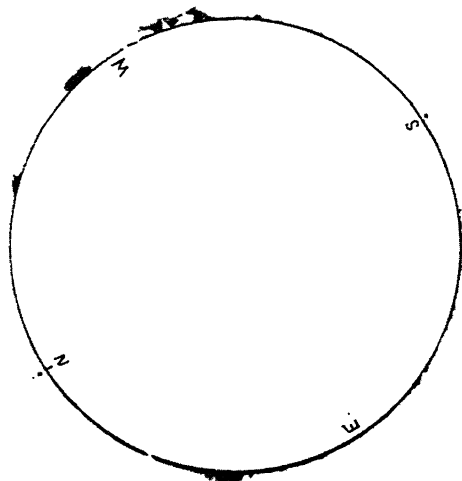
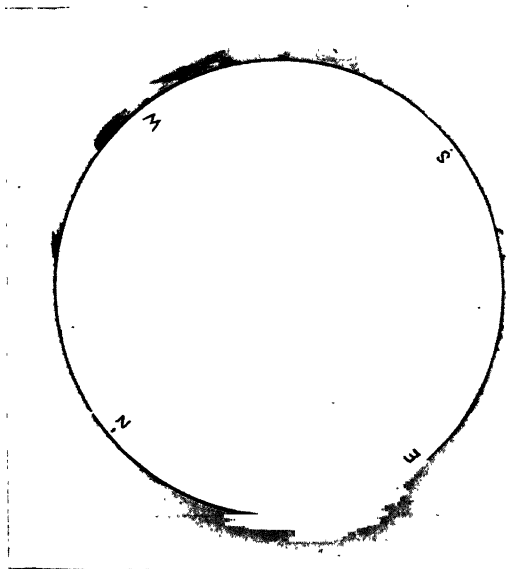


Fig. XII (a) Ca.

Fig. XII (α') H α .



Fig. XII (b) Ca.

Fig. XII (b') H α .

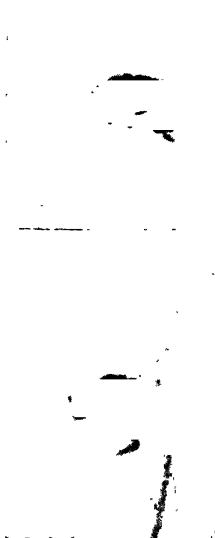
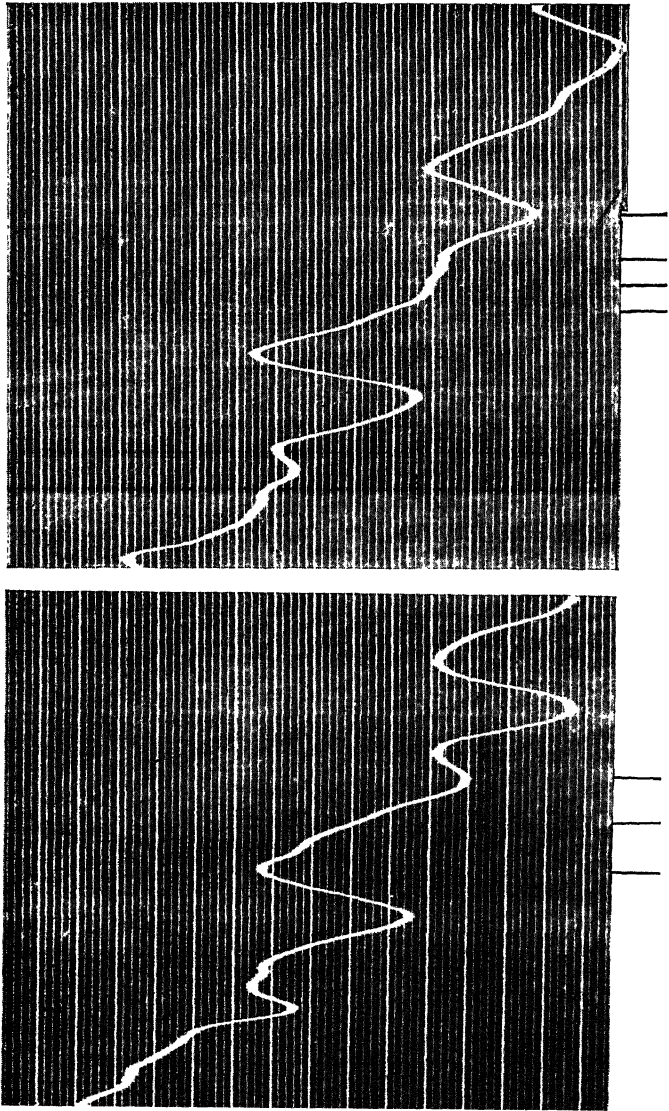


Fig. XII (c) Ca.

Fig. XII (c') H α .

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Fig. XIII.



$Q_z, L.P.$
5231 ($^3P_1, ^3P_0$); 4985 ($^3P_1, ^3P_1$).

Section of Mathematics and Physics.

Abstracts.

1. On the equilibrium between radiation and matter.

A. GANGULI, Chandernagore.

The classical statistical method of treatment of equilibrium between radiation and a black body leads to the Planck's Radiation law [Ganguli—*Z. f. Phys.* 66, 137 (1930)]. By considering, however, that matter is partly annihilated and converted into radiation, we obtain Stern's formula [*Z. Elektrochem.* 36, 448 (1925)] by considering an equilibrium between neutral matter and radiation. If, however, we consider the annihilation process according to the scheme :



and assume that the free energy of the electron is equal in magnitude but opposite in sign to that of a proton [Jordon, *Z. f. Phys.* 41, 711 (1927)], we obtain the following formula :

$$n = \left(\frac{2\pi (m M)^{\frac{1}{2}} kT}{h^2} \right)^3 e^{-\frac{(m+M)c^2}{2kT}}.$$

The process is reversible and the reverse process of conversion of radiation into matter at the outer stellar atmosphere is also suggested. It is, however, seen that the second mechanism of annihilation offers some difficulty as regards the conservation of momentum, so it is suggested that matter is directly annihilated.

Using relativistic statistical mechanics, we arrive at the following interesting formula for the number of particles in equilibrium with radiation :

$$n = 8\pi \frac{k^3 \tau^3}{h^3 c^3}.$$

This is identical with the total number of photons as calculated from the radiation law for $h\nu \gg kT$. Again by proceeding in a reverse way, one is led to Stern's result from the radiation law if radiation is considered to be isotropic.

2. On the generalised formula for Thermal Ionisation.

A. GANGULI, Chandernagore.

Recently Chandrasekhar [*Phil. Mag.* 9, 292 (1930), *M.N.*, 91, 446 (1930)] and others have proposed generalised ionisation formula for degenerate case. Chandrasekhar and others, however, come to the conclusion that matter in that condition and at temperatures of order of 10^9 and number density 10^{30} is not ionised at all. This is in direct contradiction to the assumptions of Eddington, Fowler and others. The author has recently deduced the following formulæ :

$$(1) \quad \ln \frac{n}{n_+} = \frac{\chi}{kT} + \frac{4.453 \times 10^{-11}}{T} n_-^{\frac{2}{3}} - \frac{1.845 \times 10^{10} \times T}{n_-^{\frac{2}{3}}}$$

(Non-Relativistic electrons degenerate).

$$(2) \quad \frac{n_+ n_-}{n} = 8\pi \frac{(kT)^3}{h^3 c^3} e^{-\frac{\chi}{kT}} \quad (\text{Relativistic, Non-degenerate}).$$

$$(3) \quad \ln \frac{n}{n_+} = \frac{\chi}{kT} + \frac{hc}{kT} \cdot \left(\frac{3}{4\pi} \right)^{\frac{1}{3}} n_-^{\frac{1}{3}} - \frac{\pi^2}{3} \cdot \frac{kT}{hc} \left(\frac{4\pi}{3} \right)^{\frac{1}{3}} \left| n_-^{\frac{1}{3}} \right|$$

(Relativistic, electrons degenerate).

Now instead of identifying the number of free electrons with the number of particles calculated from the density, as was done by Chandrasekhar, we consider the latter to be the sum of the neutral atoms, ions and electrons. If Z is the atomic number and x the degree of dissociation, we then have

$$n = \frac{(1-x)}{1+Zx} \cdot N, \quad n_+ = \frac{x \cdot N}{1+Zx} \quad \text{and} \quad n_- = \frac{Zx \cdot N}{1+Zx}$$

where N is the number of molecules calculated from the density. Introducing these values in the above equations, we obtain by graphical methods complete dissociation at temperature within 10^{10} degree for $N=10^{30}$ in the case of common stellar elements. This is in agreement with the assumptions of Eddington and others. These results are also applicable to the recent stellar model proposed by Milne [*M.N.*, 91, 4 (1930)]. Again by proceeding according to a method of a previous paper [Kar and Ganguli, *Z. f. Phys.*, 61, 510 (1930)] we find that the electrons are free in the degenerate case.

3. On the stellar opacity coefficient.

A. GANGULI, Chandernagore.

In a previous paper [*Ind. J. Phys.*, 6, 453 (1931)] Kramer's formula for X-ray absorption coefficient was deduced by the author by considering an equilibrium between the photo-electrons present in a volume of effective cross section β_v and velocity range v and $v+dv$, and the number of electrons responsible for radiation. The same method is extended in this investigation, the total number of electrons having all possible velocities being taken into consideration. This leads us directly to the deduction of the values of the opacity coefficients obtained by Chandrasekhar [*Proc. Roy. Soc.*, 133A, 241 (1931)], Mazumdar and Kothari [*Astr. Nachr.*, 244, 65 (1930)] and B. Swirle [*M.N.*, 91, 4 (1930)] for the non-degenerate and degenerate case. Subsequently using relativistic statistical mechanics and using the value of the atomic absorption coefficient due to Sauter [*Ann. d. Phys.*, 11, 454 (1931)] we have obtained

the following expressions for opacity coefficient proportional to $\frac{1}{T^2}$

for the non-degenerate case and a value independent of number of electrons and proportional to T for the degenerate case:

$$N \quad a_0 \sim \frac{n \cdot a 8\pi^4 Z^5 e^{12}}{5 k^2 m^2 c^5} \cdot \frac{1}{T^2}$$

$$D \quad a_0 \sim \frac{a \cdot 2^6 Z^5 \pi^5 e^{12}}{z n^2 c^3 h^2} \cdot k \cdot T.$$

The equation for the opacity coefficient for the relativistic degenerate case is applicable to Milne's model and this indicates that the opacity increases with temperature.

4. Successive breakdown of insulating oils.

B. S. RAMASWAMI, N. V. NARAYANASWAMI, and
F. N. MOWDAWALLA, Bangalore.

Tests for the dielectric strength of oils have been known to give very erratic results even when carried out under practically identical conditions. In an attempt to devise methods for obtaining more uniform results the authors carried out tests involving 4,000 successive breakdowns on transformer oil with standard B.S.S. electrodes. These tests were repeated on oils having different degree of purity but the variations after a large number of breakdowns were found in every case to be as great as in the beginning. This is in agreement with the results of Hayden and Eddy (*Jour. A.I.E.E.*, 1922, p. 495) who report similar variations at the end of 500 breakdowns and attribute them to the complex nature of the oil. They, however, conclude that the mean breakdown voltage attains a constant value within the above number of breakdowns. The experiments carried out by the authors indicate that the mean of every hundred breakdown values does not become constant before 2,000 breakdowns. With moist oils there is an initial rise due probably to the removal of moisture, but with dry oils there is an initial fall due to the accumulation of carbon. In all cases the mean attains a constant value only after 2,000 breakdowns and this mean value is very nearly the same irrespective of the degree of moisture in the oil at the start.

5. The effect of super-imposed magnetic fields on dielectric strength.

B. NANJUNDIAH, N. V. NARAYANASWAMI, and
F. N. MOWDAWALLA, Bangalore.

Monkhouse (*Proc. Phys. Soc.*, 1928, Vol. 41, p. 83) and Smurroff (*E.T.Z.*, Oct. 16, 1930, Vol. 51, p. 1459) have determined the dielectric strength of air, oil and certain solid dielectrics in magnetic fields. Their experimental arrangement would indicate that they have worked with comparatively weak magnetic fields and their results show that these fields have a definite effect on the values of breakdown voltage, although this effect varies with different dielectrics and with the direction of the magnetic field relatively to the electric field. The authors have determined the breakdown voltage of transil oil and air using an electromagnet capable of giving field strengths of over ten thousand gauss. The experiments were made with small gaps between electrodes and D.C. magnetic fields, both longitudinal and transverse. The results indicate that the effect of D.C. fields on the dielectric strength of oil and air, if any, is negligible and within the limits of experimental error. A very large number of breakdown values were obtained. Those obtained with air were found to be quite consistent; the behaviour of oil, on the other hand, was found to be erratic but hundreds of readings taken with and without magnetic field point to the above conclusion. Further work is in progress with regard to other dielectrics and the behaviour of these in A.C. magnetic fields.

6. Taylor's frequency tripler.

P. R. PILLAI and F. N. MOWDAWALLA, Bangalore.

The explanation of its action originally offered by Taylor and accepted to-day has been amplified and some misconceptions corrected. The effect of the fifth and higher harmonics in the exciting current due to saturation of the core of the choke coil have been taken into consideration and the theory of the tripler revised on the basis of these considerations. The effect of star connections with the neutral of the

tripler (a) connected to the neutral of the generator, and (b) disconnected therefrom, has been shown by oscillographic records and discussed in the light of the explanation offered. The effects of the saturation of the transformer and the leakage between its three primary coils have been studied and discussed.

7. Current loci of the Schrage motor and an induction motor connected to an expedor phase advancer.

J. J. RUDRA.

If the iron losses and the primary resistance of the motor are not neglected, and the exciting current is taken as $(g_0 - jb_0)E$ instead of $(g_0 - jb_0)E_1$, the current loci of the Schrage motor and an induction motor connected to an expedor phase advancer are given by the equation.

$$A(x^2 + y^2) - 2Bx - 2Cy + D = 0.$$

where

$$A = x'_0 x'_1{}^2 \left(1 - \frac{C_0}{C_3}\right) + x'_1 z'_0{}^2 \left(1 - \frac{C_1}{C_3}\right) + x'_2 \left\{ (r'_0 + r'_1)^2 + (x'_0 + x'_1)^2 \right\}$$

$$B = \frac{E_1}{2} \left\{ 2x'_0 x'_1 \left(1 - \frac{C_0}{C_3}\right) + 2x'_2 (x'_0 + x'_1) + z'_0{}^2 \right\}$$

$$C = \frac{E_1}{2} \left\{ 2x'_0 r'_1 \left(1 - \frac{C_0}{C_3}\right) + 2x'_2 (r'_0 + r'_1) - \frac{z'_0{}^2}{C_3} \right\}$$

$$D = E_1{}^2 \left\{ x'_0 \left(1 - \frac{C_0}{C_3}\right) + x'_2 \right\}$$

$$z'_0{}^2 = r'_0{}^2 + x'_0{}^2; \quad z'_1{}^2 = r'_1{}^2 + x'_1{}^2; \quad C_0 = \frac{r'_0}{x'_0}; \quad C_1 = \frac{r'_1}{x'_1}.$$

For the Schrage motor :—

$$r'_0 = \frac{\gamma r_0}{t}; \quad x'_0 = \frac{\gamma x_0}{t}; \quad r'_1 = r_1; \quad x'_1 = \frac{x_1}{t}; \quad x'_2 = \frac{\gamma x_2}{t^2};$$

$$t = 1 + k; \quad C_3 = \frac{-R_2}{k(x_1 + \delta x_2)}; \quad \delta = 1 + \frac{x_1}{x_0}; \quad \gamma = 1 + k\delta;$$

k is positive for $\beta = 0$, and negative for $\beta = \pi$.

For an induction motor connected to an expedor phase advancer :—

$r'_0, x'_0, z'_0, r'_1, x'_1, z'_1$ and x'_2 are respectively equal to

$$r_0, x_0, z_0, r_1, x_1, z_1 \text{ and } x_2, \text{ and } C_3 = \frac{R_2 - a \cos \theta}{-a \sin \theta}.$$

8. Rectifying action of copper-oxide rectifiers.

ALJAZ MOHAMMED.

Specimens of copper-oxide rectifying units, having rectification ratios up to 1,300, were prepared in the laboratory. It was found that, on reducing the thickness of the active film by dissolving it in dilute nitric acid, the rectifying ratio improved up to a point beyond which it remained constant. The variation of the direct and reverse current and the change of photo-electric effect of the surface with varying thickness of the film were studied. The behaviour of the rectifier (a) under action

of dry and moist atmosphere, (b) with electrodes of different metals, (c) with varying areas of contact, and (d) under different pressures, were studied. Other experiments were carried out with the object of determining the location of the rectifying layer. The various theories of its action now current are discussed in the light of these experiments. No definite conclusion has been arrived at. Some of the results tend to confirm the theory of the rectifying layer being at the surface of the film while others point to its being next to mother copper.

9. Electro-acoustic behaviour of flames.

LAL C. VERMAN.

Sensitive flames have been shown to have a definite wave structure under the influence of sound waves. With a view to study the electro-acoustic properties of such flames, a couple of platinum electrodes were introduced into the flame and a D.C. potential applied to them through a high resistance. This combination was connected to a high-gain audio amplifier, the output of which was connected to a loudspeaker or a pair of head phones. When the output speaker or phones were brought in the vicinity of the flame, the familiar phenomena of singing telephone was observed. If a sound wave is made to impinge on the flame, a great deal of noise is produced in the output with a faint suggestion of the original tone. Experiments are in progress to eliminate this noise which is mainly due to the roaring of the flame and bring out the desired note thus making it possible to study the microphonic properties of flames.

10. A synchronised pulse generator using gas-filled tubes.

LAL C. VERMAN and ALJAZ MOHAMMED.

Several complicated methods have been used to generate short duration electrical pulses, such as an intermittent oscillator, an unbalanced multi-vibrator, an over-biased amplifier fed with A.C. The authors have found a comparatively simpler method to accomplish this purpose by using a gas-filled discharge tube. In the familiar circuit of the stabilised linear time-base generator used in connection with cathode ray oscillographs, a high ratio transformer is introduced so that the practically instantaneous discharge of the condenser through the gas tube passes through the low-tension winding of this transformer. This produces a very short train of oscillations in the secondary of the transformer. A suitable resistance in parallel with the secondary can be used to damp down this oscillation train to a practically unidirectional pulse of a duration as short as 0.0001 sec. or less. To control the duration of the pulse, a variable resistance in the discharge circuit can be introduced, while the frequency of the pulses can be controlled by the resistance in the charging line. Synchronisation can be effected by the various methods used in connection with the time-base circuits.

11. A new method of automatically and continuously recording the height of Kennelley-Heaviside Layer.

LAL C. VERMAN and ALJAZ MOHAMMED.

A synchronised pulse generator (described in another abstract) is to be used to modulate a transmitter to send out trains of radio-frequency waves, the duration of which would be of the order of 0.0001 of a second. The synchronising frequency of 150 cycles per second is chosen and is obtained by full wave rectification of the 25 cycles 3 phase line supply. At the receiving end the same 25 cycle supply is used in a similar way to synchronise a time base applied to one pair of deflecting plates of a cathode ray oscillograph. The radio signals are applied to the

focussing cylinder of this oscillograph, the cylinder being so based as to show no trace of the time base, but to put the beam in focus when the pulse arrives. This means that corresponding to the direct and all the reflected pulses we shall see dots on the screen spaced from each other, the spaces being proportional to the time retardation of each pulse. Now if a photographic film is run at a speed of about an inch per hour past the screen or in a separate camera, these spots will trace out curves corresponding to the vertical heights of various reflecting or refracting layers.

Preliminary tests on the various components of the system have given satisfactory results, and it is hoped that by the time of the Congress some actual records will be available.

12. Investigations on the ionised upper atmosphere.

S. K. MITRA and H. RAKSHIT, Calcutta.

This work is a continuation of the investigation on the properties of the ionised upper atmosphere started about two years ago. The height of the ionised atmosphere in Bengal was originally measured by the angle of incidence method, the transmitter and receiver being separated by 120 kms. and the wavelength employed 370.4 metres (*Phil. Mag.*, XII, 897, 1931). Recently a modification of the group retardation or the echo method has been adopted, the distance between transmitter and receiver being quite small—only half a kilometre in some cases. For one part of the observations, the receiving station had been a fixed one at a distance of 3.8 kms. from the transmitter and for the other part it had been a mobile one, being fitted up in a motor 'bus by which observations could be carried out anywhere within a radius of 8 kilometres from the transmitter. For some observations two mobile receiving stations had been worked simultaneously in different directions and at different distances from the transmitter. The wavelengths employed had been 45 and 75 metres. The following is a summary of the investigations made:—

1. The existence of two distinct ionised layers, the so-called E and F layers has been detected.
2. From a series of 24-hour runs, the variation of the height of the two layers, as well as the variation of the intensities of the echoes therefrom, with the hour of the day and night has been studied and the nature of the average variation in Bengal has been obtained.
3. Multiple echoes which are most prominent during sun-rise and sun-set periods have been studied and the reflection coefficient of the ionised layer has been measured.
4. The variation of the intensity of the echoes with distance from the transmitter has been studied by observations made with a mobile receiver.

13. Control of super-regeneration by neon lamp oscillations.

S. K. MITRA and B. N. GHOSE, Calcutta.

When the reaction of an ordinary triode receiver is pushed beyond a critical limit self-oscillations start in the circuit rendering the receiver inoperative. Such an oscillating triode receiver can, however, be employed for reception with greatly increased sensitiveness, if one employs the device known as Armstrong's super-regeneration. The device consists in interrupting the oscillations of the receiving circuit at frequent intervals. The interval is so chosen that from the instant of making the circuit to that of breaking the same the oscillations do not get sufficient time to build themselves up to a steady state. Under this condition the amplification produced depends not only upon the amplitude of the received signal but also upon the value of the effective negative resistance

of the circuit as well as upon the period during which this negative resistance persists. For the purpose of interruption it is of common practice to employ an auxiliary triode oscillator of supersonic frequency. This has several serious disadvantages owing to which presumably the Armstrong super-regenerative circuit has never been very popular. The present communication is on a simple method of interrupting the self-oscillations and thus controlling the super-regeneration of an oscillating triode receiver. The device employs a neon lamp and is free from the common defects of the ordinary super-regenerative circuits. It is simpler to work and is also more sensitive.

14. On deposits of metallic mercury by high frequency discharge.

D. BANERJI and R. GANGULI, Calcutta.

In the course of certain experiments on high frequency discharge in gases, it was noticed that greyish deposits in the form of rings were formed alongside the external sleeve electrodes which feed the high frequency current to the discharge tube. Investigation shows that the deposit is of mercury which obtains its access to the discharge tube from the McLeod gauge. The failure to observe the deposit by other workers is probably due to the fact that care is generally taken to prevent the mercury vapour from reaching the main discharge by interposition of liquid-air traps. Conditions for obtaining the deposit quickly and easily have been studied. The distribution of the space potential both along the axis as well as along the wall has been measured. This gives a clue to the formation of the deposits.

15. Variation of the inter-electrode capacity of a thermionic valve at high frequencies.

S. K. MITRA and B. C. SIL, Calcutta.

Investigations have been carried out to find the variation of the plate grid capacity of thermionic valves in the frequency range 5×10^8 to 5×10^7 cycles per sec. ($\lambda = 60$ to 600 cms.). It has been found that the capacity increases with the decrease of frequency. It has also been observed that the 'hot' capacity is greater than the 'cold' capacity. This result does not agree with that obtained by some previous workers in this line, e.g. Bergmann and Düring (*Annalen der Physik*, 5th series, Vol. I, No. 48, May, 1929). The causes of this disagreement have been investigated and discussed.

16. Physical significance of certain apparent irregularities in the magneto-resistance curves of nickel.

M. M. SEN GUPTA and M. S. ALAM, Cuttack.

The change of resistance of nickel in small longitudinal magnetic fields is studied with a view to determine the reality of negative changes and intersections of individual parts of resistance-hysteresis curves. It is found that the negative change is a physical reality and not an experimental error. It is a record of the previous magnetic treatment of the material, and depends on the maximum field used in a cycle. The negative change is not observed, even with a sample possessing residual magnetism at the beginning, if the maximum field, to which it is subjected during a resistance-hysteresis cycle, is below a certain value. It is suggested that the real 'zero state' of a sample is the state corresponding to its minimum resistance in a cycle.

The intersections of parts of the resistance-hysteresis curves are found to be real. As these intersections do not occur in the curves of

magnetisation, they seem to be associated with the process of electrical conduction in metals. A new field of investigations is thus opened for theoretical physicists. The existing theories of electrical conduction are unsatisfactory. The formulation of a theory, relevant with observed facts, is necessary.

17. On the construction of a stretched wire variable ratio and resistance bridge for low resistance measurement.

M. M. SEN GUPTA and M. S. ALAM, Cuttack.

The usual jockey or sliding wire contact maker on stretched wires is very troublesome and not at all satisfactory for low resistance work. A special form of contact maker for use with stretched wires has been designed in the Physics Laboratory of this college. This consists of two metal plates between which the wires pass. The plates are held together by means of spring and screw adjustments, giving an exceptionally good contact. The metal plates are mounted horizontally on pillars supported on a rectangular block of metal sliding in V-grooves. Drawings of the slider and the essential parts of the bridge are given. A photograph is also given, showing two such bridges mounted on the same box.

Using a combination of the two bridges, two constantan wires of different diameters were compared with each other. The specific resistance of nickel wire was measured by comparison with standard manganin wire. The results of these test measurements are given.

Wires up to 14 S.W.G. could be used with the slider described here. For very thick rods a slightly modified form of the slider was used. A detailed description of this modification will appear later.

18. On a method of determining coefficient of mutual-inductance measured as self-induction.

L. M. CHATTERJEE, Patna.

A method of determining mutual-inductance measured as self-inductance was introduced by Russell and Trowbridge in which the apparent self-inductances, once with the coils in series and then with a rearrangement so that the effect of mutual induction is reversed, are measured. The principal drawback is that in many cases the bridge must be capable of measuring a very much larger inductance than the value of mutual induction required.

The present method is based upon the phenomenon, first pointed out by Maxwell, that the primary inductance L_1 of a mutual-inductance M is effectively reduced by an amount

$$\Delta L_1 = \frac{M^2 \omega^2 L_2}{L_2^2 \omega^2 + S^2}$$

and primary resistance P is increased by an effective amount

$$\Delta P = \frac{M^2 \omega^2 S}{L_2^2 \omega^2 + S^2}$$

when the secondary is closed; L_2 and S are inductance and resistance of the secondary and $\omega = 2\pi \times$ frequency. This change can be measured by Heaviside's equal ratio bridge or by Anderson's bridge. Primary inductance is measured with secondary first open and then closed; next the secondary coil is introduced in the bridge and its inductances first with primary open and then closed are determined. We have then

$$\Delta L_1 = \frac{M^2 \omega^2 L_2}{\omega^2 L_2^2 + S^2} \text{ and } \Delta L_2 = \frac{M^2 \omega^2 L_1}{\omega^2 L_1^2 + P^2};$$

ERRATUM

**Proceedings, Twenty-first Indian Science Congress,
Bombay, 1934**

(Abstracts, Section V, Botany)

On p. 319, in line 12 from below, *for* 'even younger' *read* 'older'

from these eliminating ω we get

$$M^2 = \frac{S^2 L_1^2 - P^2 L_2^2}{S^2 L_1 / \Delta L_2 - P^2 L_2 / \Delta L_1};$$

this can be further simplified by a preliminary adjustment such that $P=S$; then

$$M^2 = \frac{L_1^2 - L_2^2}{\frac{L_1}{\Delta L_2} - \frac{L_2}{\Delta L_1}}.$$

It is not necessary to know the actual frequency of the source. The values of M experimentally determined according to this method with telephone as detector and valve generator as source have been found to agree well with those obtained by other usual methods.

19. On an arrangement of the atomic nuclei and the prediction of isotopes.

S. B. L. MATHUR, Bombay.

The regularities observed in the existence and abundance of atomic nuclei have been commented upon by Harkins, Beck, Barton, Latimer, and others. Such attempts are of importance inasmuch as a successful tabulation may play the same role in Nuclear Physics as Mendeleef's Periodic Table did in Atomic Physics.

All the atomic nuclei may be classified into four types according to the number 0, 1, 2 and 3, respectively, of free protons in them. Plotting the number of loose electrons against the number of α particles in the various nuclei belonging to any particular type, the isotopes, belonging to that type, of the elements will lie on slanting parallel straight lines. From the symmetry of the figures it is possible to predict the existence of hitherto unknown isotopes. Working in this way about sixty isotopes have been predicted.

20. Maintenance of oscillations by a triode with filament feed cut off.

R. L. NARASIMHAIA.

It has been found that when some types of dull emitter tubes, e.g. Cosser 215 P., Cosser 220 P., and Cosser 210 H.F., are made to generate oscillations in the usual way by inductively coupling the grid coil to the oscillatory anode coil, the oscillations continue to be maintained even when the filament battery is entirely disconnected. Under these conditions, the mean anode current as well as the oscillatory current drops to 50% to 70% of the original value, and the filament continues to glow, but with less brilliance than with the filament voltage on. This glow and the electron emission resulting therefrom appear to be maintained by the bombardment of the electrons repelled from the grid towards the filament during the portion of the cycle, when the grid is negative with respect to the filament, the energy of the bombardment compensating for the energy losses from the hot filament. A careful study of the characteristic curves of the tubes that show this behaviour does not reveal the presence of detectable amounts of any gas showing thereby that the filament is bombarded mainly, if not completely by electrons.

21. A photo-electrically maintained standard clock.

C. CHANDRASEKHARIAH.

In Short's electrically maintained free pendulum the synchronising mechanism between the 'Slave' and 'Master Pendulum' is a source

of error. In the present system, a single Master Pendulum enclosed in a thermostatically controlled vacuum chamber is proposed. Instead of employing a Slave clock to provide the energy to release the falling weight once every half minute, a photo-electric cell transmitting an impulse at each swing of the pendulum is employed for this purpose, thus eliminating the error due to synchronising mechanism. A clock of this type but without the vacuum chamber has been constructed and it is hoped that some results as to its accuracy will be available shortly.

22. Distribution of potential on insulator strings.

S. N. CHATTERJI, J. S. WASON, and F. N. MOWDAWALLA,
Bangalore.

An attempt has been made to obtain uniform distribution of potential on a suspension insulator string by means of grading discs. The effect of various combinations of discs as regards size, position on the string, and number of discs simultaneously employed, has been studied. Practically uniform distribution of potentials has been obtained in some cases on strings of five and eight units. These results compare favourably with those obtainable with the use of grading rings and arcing horns in accordance with present-day practice. Some of the results indicate that in addition to the capacities between the line, intermediate units, and earth, there may be other factors affecting the potential distribution. The work is proceeding.

23. Saturation of longitudinal magneto-resistance in nickel.

M. M. SEN GUPTA and M. S. ALAM, Cuttack.

The saturation of the change of resistance of nickel in longitudinal magnetic fields is examined experimentally. Values of the original resistance, the saturation resistance, and of the maximum field for saturation are given for a number of samples of nickel wire. Values of the percentage change of resistance at saturation are also given. The saturation resistance seems to depend on the previous magnetic treatment of the material. The field required for the saturation of the magneto-resistance effect varies within certain limits. Curves are given, showing the change of resistance against the first and higher powers of the magnetic field. An approximately quadratic law seems to be obeyed.

24. The automatic electric tea maker.

B. D. VIJMANI, Bombay.

This paper deals with a novel type of a machine for preparing tea automatically. The kettle is entirely of a new design into which milk, water, and tea leaves are stored in their respective compartments before going to bed. A little time before it is required to have tea, electric current into the machine is switched on automatically by means of a time switch, and water and milk start boiling together. When the water has passed the boiling point, the tea leaves drop into the boiling water automatically, and boil there for about three minutes, after which time the milk and tea, automatically mixed in proper proportions, pour out of the kettle automatically into a cup placed on the machine. When the cup is filled with hot tea, a bell rings up and also a lamp lights up, if it be dark, and the tea automatically stops pouring into the cup.

The Automatic Electric Tea Maker employs a novel electrical circuit and a metal for heater element entirely on which the successful working of the kettle depends.

25. Nuclear spin of caesium.

B. VENKATESACHAR and L. SIBAIYA.

On the basis of the relative intensities of the components of some lines of the series $6^2S_{\frac{1}{2}} - m^2P_{\frac{1}{2}, \frac{3}{2}}$ of CsI, different investigators have ascribed to the nucleus of the caesium atom different nuclear spin moments varying from $\frac{1}{2}$ to $\frac{3}{2}$. By applying the multiplet intensity rule of Burger and Dorgelo (*Z.P.*, 23, p. 258, 1924) and assuming according to other observers that the $^2P_{\frac{1}{2}, \frac{3}{2}}$ levels have unresolvably small separation, the intensity ratio of the two components of each line in the series becomes $\frac{i+1}{i}$ (i being the nuclear spin), agreeing with the value obtained by Fermi from quantum mechanical considerations (*Z.P.*, 60, p. 320, 1930). Self-absorption in the sources so far employed has a tendency to equalise the intensities of the two components, resulting in the ascription of a high value to the nuclear spin.

The structure of the doublet $6^2S_{\frac{1}{2}} - 7^2P_{\frac{1}{2}, \frac{3}{2}}$ has been examined in the radiation from a special source where self-absorption has been almost entirely eliminated with the view of obtaining the components in their true relative intensity. The nuclear spin of caesium has been fixed from intensity measurements of the patterns.

Since in each of the lines the stronger component is on the longer wavelength side, the fine levels of $6^2S_{\frac{1}{2}}$ are erect. Their separation is found to be 0.298 cm^{-1} agreeing with the results of Jackson (*P.R.S.*, 121, p. 432, 1928). In some patterns a wing on the shorter wavelength side is observed for both the components, indicating the possibility of the inversion of the $^2P_{\frac{1}{2}, \frac{3}{2}}$ fine levels.

26. Nuclear spin of cadmium isotopes.

B. VENKATESACHAR and L. SIBAIYA.

According to Schüller and Brück the two odd isotopes 111 and 113 of cadmium have a nuclear spin moment of $\frac{1}{2} \frac{h}{2\pi}$ and the remaining even isotopes have all zero nuclear spin. The structure of some prominent arc lines have been accounted for on this hypothesis; yet a few other equally prominent lines do not conform to these assumptions. Albright (*P.R.*, 36, pp. 847-854, 1930), while drawing attention to the inadequacy of Schüller's hypothesis, calls in question the existence of a satellite at -0.060 cm^{-1} for the line 4800 ($5^3P_1 - 6^3S_1$); but our analysis shows indubitably the existence of this satellite. A mercury arc lamp with a small amount of cadmium gives the CdI lines with negligible self-absorption and the satellites appear with correct relative intensity (Venkatesachar, *Z.P.*, 75, p. 676, 1932). The efficiency of this source will be clear when mention is made of the fact that in the case of 5086 Å Schüller gives only two satellites at -0.290 cm^{-1} and $+0.106 \text{ cm}^{-1}$ (*Z.P.*, 67, p. 433, 1931), while we get an extra satellite at -0.037 cm^{-1} as required by theory (*P.R.*, 34, p. 1405, 1929).

In addition to the satellites coming under the Schüller scheme we have observed other faint satellites, which may be tentatively explained by assuming the existence in small quantities of a new odd isotope (115) with a nuclear spin of $\frac{1}{2} \frac{h}{2\pi}$. A satisfactory scheme with erect fine levels has been worked out. However while there is no doubt of the existence of some of these faint satellites (e.g. -0.181 cm^{-1} of 5086 Å: Venkatesachar, *Cur. Sc.*, 1, p. 10, 1932), the existence of others requires confirmation. Other aspects concerning the nuclear spin theory in relation to the struc-

ture of some CdII lines like 6438 Å and the polarisation of the resonance radiation of cadmium are discussed.

27. On the anomalies in the interpretation of the hyperfine structure of mercury lines.

B. VENKATESACHAR.

The hyperfine structure of mercury lines has been the subject of a large number of investigations but it is only recently that a theoretical explanation has been put forward. Schüller and Keyston, Murakawa, and Schüller and Jones have published their interpretations of the hyperfine structure of a large number of mercury lines, based on the hypothesis of a spin of $\frac{1}{2}$ and $1\frac{1}{2}$ for the odd isotopes 199 and 201, and 0 for the even ones. The results of these authors are essentially the same, although the numbers given by Murakawa differ sometimes from those given by Schüller and his collaborators. But these researches cannot be taken as giving a unique and complete explanation of the observed hyperfine structure. Firstly, in some cases, their observed hyperfine structures differ considerably from those given by previous observers. Those of Nagaoka and Mishima are the foremost among the latter and their results have to be taken as reliable in general, for more recent investigators like Görlich and Lau agree with them in many cases; also Murakawa himself in his first investigations got results agreeing with their analysis. Schüller and his co-workers base their conclusions largely on the intensities of the components; yet the experimentally observed intensities given by observers like Tolansky—whose results cannot be criticised on the score of reversal or absorption or insufficient resolving power—do not agree with theoretical predictions, although Schüller and his co-workers always seem to get the correct intensities except perhaps in the case of 5461 Å. Thirdly—and this is quite important—the assignment of some of the components of 5461 and 4358 as well as of 5791 and 5770 to the odd isotopes cannot be reconciled with their Zeeman effects observed by Nagaoka and Takamine and by Lunelund. The Zeeman effect, however, is in agreement with the theory in the case of 4047 and 2536. T. S. Subbaraya and T. G. Srinivasa Iyengar, working in the writer's laboratory, put forward a scheme to explain some of the structures, starting from the structure of 4916 found by the writer and Sibaiya. In the case of 5791 and 5770 their interpretation accords with Zeeman effect data. Their scheme gives the positions of the satellites correctly in agreement with Nagaoka's results but the relative intensities are not always correctly represented. Hence a complete investigation which takes into account the Zeeman effect and which enables us to understand the irregular changes in the observed intensities seems to be a necessity in any attempt towards the solution of the problem presented by the complicated hyperfine structures of elements like mercury.

28. The resonance spectrum of hydrogen.

K. B. RAO and J. S. BADAMI.

In the course of experiments on the spectrum of arsenic with the Paschen hollow cathode discharge, photographs have been obtained showing the Lyman series of hydrogen very strongly developed; the series is traceable down to the fifteenth member. The peculiar feature has been noticed that the intensity, instead of diminishing with successive members as in the case of a normal series, is enhanced markedly at the 10th and 11th members and then abruptly falls off, indicating the occurrence of a kind of resonance phenomenon. Further experiments have shown that this anomalous feature disappears in the absence of arsenic in the discharge tube and appears more markedly with increasing pressure of arsenic vapour. The explanation is suggested that the phenomenon

is caused by a transfer of energy by collisions of the second kind between the arsenic atoms in the metastable state of As II and the atoms of hydrogen. This explanation is supported by the equality of the excitation energies involved. A new type of impact is thus demonstrated in the occurrence of this phenomenon, for the energies of ionisation and excitation of one atom are simultaneously transferred to another atom by a single act of collision.

29. On the first spark spectrum of arsenic.

A. S. RAO.

The spectrum of arsenic has been studied under varying conditions of excitation and lines belonging to the singly-ionised atom have been identified. Combinations between the deep terms of the singlet and triplet system of As II have been discovered and with a knowledge of the intervals of the deep $5s^3P$ term, the chief triplet and singlet terms due to the $5p$ configuration have been established. The triplet terms involving the transition of one of the inner electrons have also been identified. Interesting cases of inter-penetration of the sub-levels of different terms have been observed. The largest term $4p^3P_0$ leads to an ionisation potential of 20.1 volts.

30. Further doublets in the spectrum of As V.

A. S. RAO.

As an extension of the four pairs of lines forming the first members of the doublet series of As V reported by Sawyer and Humphreys, the combination $5s^2S_1 - 5p^2P_{1,2}$ has been identified. The regular and irregular doublet laws are found to hold good to a close degree in the Cu-like spectra. The identification is supported by the detection in exactly the calculated region, of the inverted doublet $4d^2D - 5p^2P$. The occurrence of these pairs of As V in a simple discharge tube leads one to think that as a method of excitation of spectra this simple source affords a very wide range of ionisation of the atom, for example, from As I to As V.

31. Further investigations on the arc spectrum of arsenic.

A. S. RAO.

By photographing the spectrum of arsenic by the method of the hollow cathode discharge in helium or neon, several new lines have been recorded. In the light of this experimental data the analysis of As I published by previous investigators has been considerably altered and extended. Several new levels have been added and higher members of the chief groups of the ms series of terms have been identified. Interesting anomalies have been detected in the intervals of the $4d$ terms, although the usual order of increasing term values, i.e. 4P , 4D , 4F has been found to exist. A mean value of 85000 cm^{-1} has been suggested for the deepest term $4p^4S_2$ which leads to the first ionisation potential of approximately 10.5 volts for arsenic.

32. The ground configuration in doubly ionised mercury.

T. S. SUBBARAYA, Bangalore.

A number of 'displaced' series have been discovered in the first spark spectrum of mercury; the terms of these series can be represented by the formula

$$T = A + \frac{4R}{n + \alpha + \frac{\beta}{n^2}}^2$$

Now the constant A for the $2\bar{D}5/2$ series arising from the configurations $5d^9 6s$ *np* should represent the difference between the limit of this series (viz. 3D_3 of Hg III) and the limit of the ordinary doublet series (viz. 1S_0) which obey the Ritz formula. The term values in Hg II have all been calculated from the 1S_0 term of Hg III as zero and it is found that A is positive and equal to about 31000 cm^{-1} . This means that 3D_3 of Hg III is deeper than 1S_0 by about this amount. If the three lines 1994.72 (6), 2369.89(0), and 1665.3(1) are interpreted as combinations of 1P_1 , 3P_1 , and $^3\bar{D}_1$ respectively with 1S_0 , the value of the latter comes out to be 33572. Since according to this the terms due to $5d^9 6s$ are seen to be deeper than those due to $5d^{10}$ we should expect the ground configuration in Hg III to be $5d^9 6s^2$ corresponding to the case of Pt I. Terms arising from this configuration have been located and found to be deeper than those of $5d^9 6s$.

33. On the first spark spectrum of gold.

B. V. RAGHAVENDRA RAO, Bangalore.

Some of the lines of the first spark spectrum of gold have been analysed by McLennan and McLay by the consideration of the electronic configurations ($5d^9 6s$), ($5d^9 6p$), and ($5d^9 7s$). A few terms of ($5d^9 6d$) configuration together with a few of ($5d^8 6s^2$) configuration have also been tentatively fixed by them. In the present paper other terms belonging to the above two configurations have been located, and the relative positions of these terms in comparison with those arising from similar configurations in Cu II, Ag II, and Hg III are discussed.

34. An investigation of the fine structure of spectrum lines of magnesium in the visible and the ultra-violet regions.

WALI MOHAMMAD, Lucknow.

Several lines have been investigated with the help of Quartz Lummer Plates of large size and high resolving power and employing a special arc in vacuum. The structure of most of these lines especially in the ultra-violet region has been found for the first time.

35. On the structure of 3776 Å of Tl.

A. L. NARAYAN and A. S. RAO, Kodaikanal.

The H.F.S. of the arc lines of Tl has recently been analysed by Schuler and Keyston, Jackson and the authors, and is theoretically interpreted on the hypothesis of a nuclear spin. of $\frac{1}{2} \left(\frac{h}{2\pi} \right)$ for the two

isotopes 203 and 205. Schuler and Keyston found no isotope displacement for 3776 ($6^2P_1 - 7^2S_1$) while for 5351 they found a shift of about -05 cm^{-1} . By examining the radiation from a specially constructed vacuum arc, the writers found the line to be a group of six Satellites. From a consideration of the distribution of the Satellites, the complex structure of the line is theoretically interpreted, by assigning an almost similar isotope shift as in 5351 Å.

36. On the nuclear spectrum of As.

A. L. NARAYAN and A. S. RAO, Kodaikanal.

In a recent paper in the *Proc. Roy. Soc. Tolansky* published an account of the H.F.S. of some lines of the first spark spectrum of arsenic.

One of the authors has recently analysed the gross multiplet structure of this spectrum and with a view to verify the analysis. The H.F.S. of all the lines lying in the region 6500 Å to 4000 Å has been examined using quartz and glass Lummer plates and fused silica etalons. The results obtained indicate that the H.F.S. observed by Tolansky differ considerably from those of the authors. The nuclear spectrum moment of As atom has nevertheless been fixed as $\frac{3}{2}$ from a consideration of the structure of the lines and intensity measurements of the patterns. The conflicting results obtained by Tolansky are probably due to the insufficiently exposed photographs.

37. Multiplet intensities in the solar and laboratory spectra.

A. L. NARAYAN, Kodaikanal.

Quantitative intensity measurements have been carried out on the quintet and triplet multiplets of Ni I in the solar spectrum and laboratory emission and absorption spectra. Though a large majority of the lines in the solar spectrum are of anomalous intensity, the conclusions drawn by Woolley from his observations on the Ti spectrum (*A.P.J.*, Vol. LXXII, p. 256) do not seem to be borne out.

38. On the H.F.S. of Br II lines.

A. L. NARAYAN and A. S. RAO, Kodaikanal.

The hyperfine structure of Br II lines has been examined using as source (a) electrodeless discharge, and (b) Giessler tube. The relative intensities of the observed components of the lines belonging to $^5S^5P$; $^5P^5S$; $^3S^3P$ have been measured. And it has been found from these data that the nuclear moment of Br atom is $\frac{3}{2}\left(\frac{h}{2\pi}\right)$.

39. Effect of dissolving non-electrolytes on the constitution of water.

I. RAMAKRISHNA RAO, Waltair.

This is an extension of the work on the Raman-effect in solutions of electrolytes in water. Non-electrolytes like acetone also seem to get associated with water on solution, as is evidenced by the change in the structure of the Raman band for water with concentration. Evolution of heat during solution strongly supports the idea of association.

40. On the possibility of studying electrolytic dissociation of salts by the Raman-effect.

I. RAMAKRISHNA RAO, Waltair.

Hitherto, the application of the Raman-effect to the study of electrolytic dissociation in nitric acid has been reported. Extension of this work to the case of salts like sodium and ammonium nitrates indicates that higher dispersion spectrographs have to be used, as it is found that the Raman lines corresponding to the undissociated molecules and the dissociated ions are too close to permit of any accurate intensity measurements.

41. Raman frequencies in excited molecules.

B. K. VAIDYA.

Under the influence of absorbed light a change is generally brought about in the energy level of a molecule and the absorbing group in the

irradiated molecule is excited. If this excitation does not produce fluorescence or photochemical change, the molecule would remain at the higher energy level and the absorbing group would vibrate with an energy which is different from the original ground state. It should then be possible to detect both of these frequencies in the Raman spectra of the molecule under suitable experimental conditions. It is only necessary to compare two spectrograms of the same substance, one taken with the exciting radiations cut off by means of a suitable filter and the other while these radiations are being absorbed.

Experimental data to test this view are, however, very meagre, as very few investigators have employed ultra-violet light for exciting Raman spectra. The chief reason for this is that in many cases photo-decomposition or fluorescence sets in.

Figures which are available for ethyl alcohol, acetic acid, and ethyl formate appear to support the hypothesis, and it is suggested that investigations should be extended to as wide a range of substances as possible.

42. Raman spectra of some glycols and aromatic ethers.

G. V. NEVGI.

The Raman effect has been investigated in the following compounds: (1) ethylene glycol, (2) alpha propylene glycol, (3) beta butylene glycol, (4) anisole, (5) phenetole, (6) anethole.

In glycols, the frequencies in the region below 700 cm^{-1} are due to the transverse vibrations of the carbon atoms, those between 700 and 1300 to longitudinal vibrations of the same, and those between 1300 and 1500, and 2800 and 3000 to the transverse and longitudinal vibrations of the C-H linkage respectively. The strong frequencies of 863 in ethylene, 837 in propylene, and 782 and 850 in butylene glycol are due to the oscillations of the oxygen atom at the end of the chain.

Anisole and phenetole are monosubstituted and anethole a disubstituted benzene derivative. The constant benzene ring frequencies in these compounds are as follows:—

(1) Anisole	.. 610 991 1030 1176 1592 and 3061.
(2) Phenetole	.. 608 996 1023 1168 1590 and 3064.
(3) Anethole	.. 639 .. 1037 1177 1610 and 3056 and 3076. (faint)

This shows that all the benzene ring characteristic frequencies are observed in the monosubstituted derivatives, but in the disubstituted compound some frequencies are faint or even absent. Anethole shows, besides the frequency 1610 cm^{-1} (C=C in the benzene ring), a strong frequency 1659 cm^{-1} due to the C=C in the side chain.

43. The Raman effect in halogenated compounds.

G. V. NEVGI.

The Raman spectra of the following compounds have been studied: (1) N. amyl chloride, (2) isoamyl chloride, (3) tertiary amyl chloride, (4) chlorocyclohexane, (5) bromocyclohexane, (6) ethyl chloroacetate, (7) methyl trichloroacetate, (8) ethyl trichloroacetate, (9) chloromethyl ether.

The results taken in conjunction with those of previous observers show that in the normal compounds, the Raman frequency due to the C-Cl bond is independent of the length of the chain and hence that the characteristic frequency is due to inner oscillations between the carbon and chlorine atoms. A side chain in the neighbourhood of the chlorine atom reduces the frequency as shown below:—

Ethyl chloride	..	655	Iso propyl chloride	..	614
N. propyl chloride	..	651	Tert. butyl chloride	..	564
N. butyl chloride	..	650	Isoamyl chloride	..	653
N. amyl chloride	..	647	Tert. amyl chloride	..	559

A well-marked frequency at about 800, characteristic of the oscillation of the closed cyclohexane ring is also present in the chloro- (809) and the bromocyclohexane (807). The frequencies 339 in the chloro- and 263 in the bromocyclohexane appear also as anti-stokes lines.

Except for the presence of additional frequencies due to the carbon-halogen bond, the spectra of the chloro- and bromocyclohexanes resemble that of cyclohexane and the spectrum of chloromethyl ether is similar to that of methyl ether.

44. On a new method for determining the refractive indices of transparent materials.

K. PROSAD and S. SHARAN, Patna.

The method here described is suited to fairly plane-faced materials, of no more than 1 sq. cm. in area, and of thickness 1 mm. upwards. It is well known that interferometric method can be used with materials of the order of 10^{-3} cms. thickness but cannot be used with success with much thicker plates. For larger thicknesses other well-known methods are available.

When however a plate of thickness near about 1 mm. is given, the method here described is very simple for determining its refractive index. It is based on the lateral displacement of an index line which is seen through the material by means of a microscope. The displacement of the index line depends on the angle of incidence on the surface of the material, and its refractive index. If the angle of incidence and the displacement are both measured the ref. index can be obtained from the following formulæ :—

$$\mu = \frac{\sin i}{t \sin i - d} \sqrt{t^2 + d^2 - 2dt \sin i}$$

where i = the angle of incidence ; t = the thickness of the plate ; and d = the shift.

It is also possible to show to a class by means of micro-projection the shift of the index line with the variation in the angle of incidence on the experimental plate.

45. Positions of the atoms in para-dinitrobenzene crystal.

K. BANERJEE.

From a modified Weissenberg photograph and a number of oscillation photographs the space-group of para-dinitrobenzene is found to be C_{2h}^7 . Intensities of reflections from about forty planes have been measured. By trial a rough idea about the positions of the atoms is obtained. Signs of the structure factors for the different planes were obtained from this rough structure. The Fourier analysis method was employed and the complete distribution of scattering matter in the crystal was determined.

46. Analytic determination of the signs of the Fourier terms in complete crystal structure analysis.

K. BANERJEE.

Distribution of scattering matter in a crystal can be represented by means of a Fourier series whose amplitudes are the structure factors.

for reflections from different planes. In actual practice a two-dimensional projection of this is used. If the crystal has a centre of symmetry through the origin the phases of all the terms in the Fourier series can be made zero while the sign of any term may be plus or minus. For determining the distribution of scattering matter we have to know the signs of the Fourier terms. If we assume that the atoms have spherical symmetry we can write down a series of equations giving the relations between the structure factors and the normal distances between the centres of the atoms from the plane of projection. These normal distances cannot, however, be obtained by solving these equations for three reasons :

- (1) The intensity measurements are not sufficiently accurate.
- (2) The assumption of spherical symmetry may not be rigorous.
- (3) The degree of the final equation to be solved is the same as the number of atoms in the cell divided by the number of elements of symmetry. This is not solvable in most cases.

For determining the signs of the terms only, effects of (1) and (2) are negligible. Since the number of equations is very large we may eliminate all quantities except the structure factors and still have a large number of equations. It is now easy to choose the signs of the structure factors so that all the equations are satisfied.

47. Dielectric coefficients and refractivities of gases.

H. E. WATSON, G. GUNDU RAO, and K. L. RAMASWAMI,
Bangalore.

In continuation of the work on dielectric coefficients of gases already reported additional gases have been investigated, measurements of refractivity and dispersion being made simultaneously by means of a Rayleigh interferometer.

The values of $n^2 - 1$ for the gases sulphur hexafluoride, silicon tetrafluoride, carbon dioxide, and acetylene are less than those of $e - 1$. The temperature coefficient of $e - 1$ for these gases are negligible and indicate the absence of dipole moments.

48. The dipole moments of pyridine derivatives. II.

M. A. GOVINDA RAO and B. N. NARAYANASWAMY.

The moments of carefully purified piperidine, *n* methyl piperidine, propylidene ethyl amine, quinoline, iso-quinoline, and α quinaldine have been determined accurately from the temperature coefficient of their molecular polarisations in dilute solution in benzene. A special type of pycnometer has been used for measuring the densities of these solutions.

49. Absorption of light in polyatomic molecules.

B. K. VAIDYA.

From a collection of data on the band spectra of polyatomic molecules as observed in absorption, it appears that the main seat of absorption lies in the group containing the unsaturated part. This is specially true for organic molecules. This group which is necessarily a diatomic one exhibits vibrational frequencies with singlet or multiplet structure which are characteristic of the group in the free state. The number of vibrational transitions undergone by this diatomic group when forming a part of the molecule, is, however, smaller. The region covered by absorption is therefore less than the one corresponding to its band system in free state. Also, on account of the heavier mass of the molecule and loss in energy of the bonding electrons in coupling the original band system of the diatomic molecule is shifted to longer wavelengths. The following examples are quoted :—

Molecule.	Active group.	Polyatomic Frequency.	Frequency in Diatomic State.	
Formaldehyde	C : O	1180	1182	Hopfield Birge upper level.
	C : O	1723	1724	Cameron upper level.
Phosgene ..	C : O	422	2149—1724	Cameron system.
Benzoquinone	C : O	1110	1105	Merton-Johnson upper level.
			1182	Hopfield Birge upper level.
	C : O	422	2149—1724	Cameron system.
Diacetyl ..	C : O	1411	1497	4th positive upper level.
Glyoxal ..	C : O	1418	1497	4th positive upper level.
Hydrazine ..	N : N	470
Azobenzene ..	N : N	652	2345—1679	Birge Hopfield abs. system.

The argument brought out in the present paper is further substantiated by the fact that in the substances examined for the Raman spectra, characteristic frequencies of the various diatomic groups correspond to those found for the same groups in free state.

50. 'Fronts' associated with atmospheric disturbances in the Indian area.

K. R. RAMANATHAN.

The characteristic features of different kinds of 'fronts' associated with depressions and storms in the Indian area are summarised and are compared with those connected with cyclones of temperate latitudes.

51. Spectrum of the night sky.

K. R. RAMANATHAN and J. V. KARANDIKAR.

Besides the yellow-green line 5577 Å, other 'lines' or 'bands' are also generally observable in the spectrum of the moonless night sky in India. The most prominent of them agree with those observed in temperate latitudes by Slipher, Rayleigh, and Dufay, and cannot therefore be attributed to the occasional presence of auroral discharges. Theories of the origin of these 'lines' or 'bands' are considered.

The available evidence regarding the variation of the intensity of the green line during night in different parts of the world is discussed.

52. On hydraulic seismographs.

S. K. BANERJI and K. N. SOHONI.

Prof. Kapitza (*Proc. Roy. Soc.*, Vol. 131-A, p. 224, 1931) used certain hydraulic device in the construction of a balance for the measurement of the magnetisation and suggested that the same procedure might prove useful for the recording of earthquakes. In order to explore the possibilities of this type of instrument for the recording of earthquakes, a series of comprehensive experiments was carried on in the Colaba Observatory. The apparatus for recording the vertical component consists of an in-

verted cylindrical cup, its lower face being closed by a thin metal membrane and a narrow opening being provided at one side in which a mirror is suspended from an axle. A cylindrical jacket covers the cup all round except the membrane at the bottom. Some highly viscous oil, such as castor oil, is then poured into the double chamber, so as to fill up completely the inner chamber and the membrane is then loaded by attaching weights to a rod fixed at its centre. The vertical component of the ground movements sets up oscillations in the membrane and forces the oil to move to and fro through the narrow opening and thus gives a large oscillatory angular motion to the mirror, which is recorded photographically. Although the highly viscous oil makes the system almost aperiodic yet the low free period of the system makes the instrument not very sensitive in picking up the long period earthquake waves. The instrument is however highly sensitive to artificial vibrations of the ground and is therefore very suitable for geophysical prospecting. It gives also good records of the sustained vibrations of the ground, such as micro-seisms. If the chambers be so arranged that the membrane is in the vertical plane and is loaded with two symmetrical weights fixed at both ends of a horizontal rod passing through its centre, the instrument records the horizontal component of the ground movements. The sensitivity to earthquakes of the instruments for vertical and horizontal components is increased if the free period of the system is increased by using membranes of very large diameters.

53. Artificial vibrations of the ground.

S. K. BANERJI and M. D. MANOHAR.

When we drop a known weight from a known height we communicate a definite energy into the ground. We can calculate the vibrations produced in the ground, assumed to be isotropic, by an impulse of this kind and compare them with the observed results. The ground movements at various distances from the source of disturbance were recorded by two horizontal components (N-S and E-W) seismographs of the Milne-Shaw type (period 12 seconds, damping ratio 20 : 1) and a vertical component seismograph (period 3.6 seconds), all locally constructed. All the three components were recorded on the same sheet of photographic paper kept quickly moving by clockwork. The movement in all the three components begins with a sudden impulse and is followed by oscillations having compound periods composed of the free periods of the small building in which the instruments are housed and the forced periods of the ground due to the dropping of the weight. The amplitude of the horizontal component of the ground movement is found to decrease with distance approximately according to the theoretical law (distance)^{-1/2}. The periods of the forced movement of the ground depend on the duration of impact and the elastic constants of the ground and the theoretical values agree fairly closely with the observed values. When a weight of 130 kilogrammes meets the ground with a velocity of 4 m/s, the amplitude of the horizontal component of the ground movement at Colaba is about 12μ at a distance of 10 metres and 5μ at 20 metres and the period of the forced vibrations is about 0.05 sec. The free period of the building is 0.014 sec.

54. Electric charge on individual drops of rain.

S. K. BANERJI and S. R. LELE.

More than a year ago an apparatus was set up in the Colaba Observatory for recording the electric charge on individual drops of rain. Rain drops in order to have access into an insulated receiver have first to pass through a cylindrical funnel having a narrow opening of diameter 1.4 cm. and then through a second opening of diameter 2.4 cm. at the periphery of a rotating disc. Both openings are provided with trap arrange-

ment so that if a drop strikes the sides it is caught and led away. The diameters of the openings have been determined by trial so that in an ordinary shower only a single drop will fall into the receiver at a time. A delicate manometer attached to the receiver keeps a record of the size and number of drops. For recording the charge given to the receiver by each drop of rain, a Wilson tilt electroscope is used and the movement of the gold leaf is photographed by allowing light from a point source to pass through a short-focus lens and a pin-hole made in the gold leaf. The speed of the rotating disc is so adjusted that a second drop may not enter into the receiver until the charge of the first has been recorded and the speck brought to 'zero' by an automatic earthing device. Simultaneously with the above apparatus, a Simpson apparatus giving the charge of rain collected every two minutes was kept in action. An analysis of the records shows that both positively and negatively charged drops are present in rain. When the rain received during any interval is positively or negatively charged as a whole there is an excess of positively or negatively charged drops. In non-thunderstorm rain, the mean charge of drop was ± 0.6 e.s.u., the maximum $+2.0$ e.s.u. and -3.4 e.s.u. and the minimum ± 0.06 e.s.u. In thunderstorm rain, the mean charge of drop was $+0.4$ e.s.u. and -0.7 e.s.u., the maximum $+2.3$ e.s.u. and -3.8 e.s.u., and the minimum ± 0.07 e.s.u.

55. Latent instability in the atmosphere revealed by some Indian tephigrams.

V. V. SOHONI and MISS M. M. PARANJPE, Poona.

A curve of saturation temperatures, termed the estigram (S-T gram; saturation temperature-gram), has been suggested some time ago by Dr. C. W. B. Normand as a useful method of indicating humidity, from the thermodynamic point of view. By the application of this method of indicating humidity about 275 sounding balloon records over Agra, Poona, and Hyderabad mainly collected in the period 1929 to 1931 by the India Meteorological Department were studied from the point of view of latent instability. An absence of layers of latent instability in winter and their frequent occurrence in the pre-monsoon and monsoon periods were observed in the atmosphere over Agra. Soundings over Poona also showed absence of liability to latent instability in winter; but the available soundings for the monsoon months were too few to arrive at any definite conclusions. For Hyderabad where soundings for the period June to November, 1929 and 1930, only were available, marked latent instability was found to be most frequent in the monsoon and post-monsoon periods.

The sources of air samples relating to individual tephigrams and either exhibiting marked latent instability or no latent instability, were investigated, by tracing the trajectories of upper air movement from the results of the pilot balloon flights of the Indian net-work of stations at various levels. These trajectories indicate that at Agra generally, incursions of oceanic air are associated with marked latent instability; this is also true for Hyderabad for the period June to November: while for Poona the chances of the association of marked latent instability with oceanic air are approximately 2 to 1. The association of continental air with absence of latent instability is also apparent from Poona and Agra results. Further detailed study is in progress.

56. Study of squalls in relation to aviation.

B. N. BANERJI and P. R. KRISHNA RAO.

A number of the minor accidents to aeroplanes while landing and to airships while approaching the moorings are believed to be attributable to unusual gustiness of winds or to squalls.

The paper first describes the normal wind fluctuations in gusty winds and then the nature of the squalls and the probability of their occurrence during particular weather situations or seasons. The study of squalls takes into consideration all occasions of sudden changes of wind velocity of the order of 20 m.p.h. or more and is based on all available records of self-recording instruments at the observatory at Karachi Air Port and the synoptic charts for the last four years.

57. On pendant drops.

L. SIBATYA and H. S. VENKATARAMIAH.

Lord Rayleigh (*Phil. Mag.*, 48, pp. 321-337, 1899) in his investigations on capillarity remarks that, in determining the surface tension of a liquid by the weight of a drop delivered from a vertical tube, 'sufficient time must of course be allowed for the formation of the drops; otherwise no simple results could be expected'. Later investigators have concluded that the drop weight will be too large if the drop is formed fast, a total time of formation of about 10 minutes for each drop being requisite. The effect on the magnetic susceptibilities of liquids by the drop weight method due to the variation of the drop weight with the time of formation has been discussed in a separate paper (in print, *Ind. Jour. Phys.*). Experiments have shown that the drop weight W could be expressed by the empirical formula

$$W = A + \frac{B}{t + c},$$

where t is the time of formation and A , B , and c are constants. This relation agrees with the one given by Abonnenc (*C.R.*, 168, 556, 1919) which is a series expansion of W in terms of the drop frequency. If three determinations of W are made with different values of t

$$A = \frac{\Sigma W_1 t_1 (W_2 - W_3)}{\Sigma t_1 (W_2 - W_3)},$$

where A is the weight of a drop with an infinite time of formation. Using this value of A with the corrections given by Harkins and Brown (*J.A.C.S.*, 499, 1919), an accurate value of surface-tension is obtained. Values for the surface-tension of some liquids like water, benzene, etc. are given. The theoretical significance of the constants B and c is discussed.

58. Size of the liquid drops on the same liquid surface.

L. D. MAHAJAN, Patiala.

In this paper, the author has studied those factors which increase the size of the liquid drops on the same liquid surface. It is found (i) that the size of the primary drops floating on the same liquid surface, formed by the burette method, depends upon the diameter of the jet attached to the end of the burette. The greater the diameter of the jet, the greater is the size of the drops formed, and (ii) that the size of the primary and the secondary drops formed by any method, depends upon the surface tension of the liquid. The greater the surface tension of the liquid, the greater is the size of the drops.

It is also found that the viscosity and the density of the liquid have no effect on their size. Various experiments which support the above conclusions were performed with various liquids. The curves are also drawn to show the exact relationships of these two factors with the size of the drops.

59. Life of liquid drops on the same liquid surface.

L. D. MAHAJAN, Patiala.

In this paper, the author has studied in detail, the various factors which affect the life of liquid drops on the same liquid surface, and has given the description of the various experiments which were performed to show their effects. The following conditions which prolong their life were found :—

- (i) Vibration of the liquid surface.
- (ii) Motion of the liquid surface.
- (iii) Movements of the liquid drops.
- (iv) Addition of more viscous substance to the mother liquid.
- (v) Viscosity of the mother liquid.
- (vi) Absence of impurities in the surrounding medium.
- (vii) Saturated vapours of the mother liquid.
- (viii) Surface viscosity of the mother liquid.

The vibrations and the motion of the liquid surface, and the movements of the liquid drops increase their life. Addition of more viscous substance to the mother liquid and the higher viscosity of the surrounding medium also prolong their life. The impurities in the surrounding medium make them most unstable but the presence of the saturated vapours make them very stable. The surface viscosity of the mother liquid also affects them.

60. Effect of temperature on the liquid drops.

L. D. MAHAJAN, Patiala.

In this paper, the author has studied in detail the various effects of temperature on the liquid drops on the same liquid surface. Various liquids are tried and the following effects, according to the classification of the liquids, are studied :—

1. If soap or phenyle solutions are heated, the formation of such drops becomes almost impossible.
2. If water be heated, the formation of such drops becomes a little easy.
3. Inorganic substances, their solutions, and syrupy liquids are not effected the least by the increase of temperature.
4. Light liquids, as for example ether, turpentine, alcohol, do not show any remarkable difference in the formation of such drops.
5. If the temperature of the oils and fats be increased, it makes the formation of the primary and the secondary drops very easy and prolongs their life but decreases their size.

Various experiments are performed which supported the above results.

61. Effect of the disturbing factors on the liquid drops on the same liquid surface.

L. D. MAHAJAN, Patiala.

In this paper, the author has studied the various factors which disturb the phenomenon of the liquid drops on the same liquid surface. It is found that the following factors instead of helping this phenomenon makes the formation of such drops most difficult and the drops, if any formed, most unstable :—

- (i) Impurities on the surface of the mother liquid.
- (ii) Impurities in the mother liquid.
- (iii) Impurities in the surrounding medium.
- (iv) Electric charge.
- (v) Rise of temperature (in case of the soap and phenyle solutions).

All the above factors are studied in detail, and the various experiments are performed which support the above facts.

62. The effect of low pressure on the life of liquid drops on the same liquid surface.

L. D. MAHAJAN, Patiala.

In this paper, the effect of low pressure on the life of liquid drops on the same liquid surface, is studied in detail. The description of the method applied to study this effect is also given.

It is found that the life of such drops depends upon the pressure of the surrounding air. The less the pressure of the surrounding air, the less is the life of the drops. When a partial vacuum is created in the vessel, the formation of such drops inside that vessel becomes impossible.

Moreover, the life of the drops remains almost the same for all pressures within the range for which the Boyle's law is approximately true. The results obtained are also explained in detail.

63. Theories of the liquid drops on the same liquid surface.

L. D. MAHAJAN, Patiala.

In this paper, the theory of Dr. M. Kataline is discussed in detail. The author has given his own mathematical theory and explanations for the phenomenon.

The following two experiments are performed :—

(1) The Newton's circular coloured fringes are observed when a drop is examined under a powerful microscope in the strong light of the sun.

(2) When a beam of strong light is passed between the drop and the liquid surface below, and is allowed to fall on the screen in a dark room, a fine but slightly curved strip of light is observed between the images of the drop and the liquid surface.

From the above two experiments and other results, it is concluded that there may be a fine film of air (or the surrounding medium) of uniformly varying thickness according to the shape of the drop, which may be supporting the drop resting on the same liquid surface.

64. Vibrations of different parts of the pianoforte sound-board.

L. D. MAHAJAN, Patiala.

In this paper, the author has studied thoroughly the vibrations of different parts of the pianoforte sound-board (as the sound-board consists of different pieces of seasoned wood joined together by means of ribs which run on the sound-board at an inclination).

The author has analysed their vibrations by the mechanical process of Hawley O. Taylor, (*Physical Review*, Vol. VI, No. 4, pp. 303-311, 1915) and has brought into light various interesting results. The author has also deduced a relation between the amplitude of the vibration of the ribs within their length.

The previous method of photographing the vibrations of the pianoforte sound-board (*Indian Journal of Physics*, Calcutta, Vol. IV, Part VI, pp. 515-531) is also improved, and various photographs of the vibrations are also taken with the new method.

65. The structure of thin films of metals.

S. RAMA SWAMY, Bangalore.

It has been known for a long time that thin beaten leaves of gold and silver lose their characteristic blue and green colours on heating and become transparent. This is because the leaves break up on heating, forming transparent 'windows'. This change in structure has been studied for thin films of gold and silver obtained by cathodic sputtering on glass or quartz. Microphotographs have been obtained of films of different thicknesses in the neighbourhood of 10^{-6} cm. The disintegration of the film depends both on its thickness and on the temperature to which it is heated; before heating, the sputtered film appears to be quite uniform and without any structure under the microscope. At about 200°C . it breaks up and forms a kind of a net work. As the temperature increases this net work further disintegrates into aggregates of metal which are separated from each other. These metallic aggregates are bigger in size for thicker films than for thinner ones. Also the temperature at which these metallic aggregates are completely separated from each other is higher for thicker films than for thinner ones. Further work on the examination of the surface structure of the films by electron diffraction methods is now in progress.

66. Cavity resonance at supersonic frequencies.

S. K. KULKARNI JATKAR.

The apparent value of wavelength corresponding to a velocity of 753 meters in air which was reported at the Indian Science Congress in 1932 has been discovered to be due to the tube acting as a Helmholtz resonator. Working with tubes of diameters 1.25, 1.1 and 0.95 cm. and apertures from 0.1 to 0.2 cm. apparent wavelengths of 0.425, 0.556 and 0.710 cm. were obtained in air at a frequency of 49.712 cycles per second. The corresponding volumes were 0.52, 0.53, 0.52 indicating that points of resonance depended on the volume of the tube rather than its length. Calculations of the conductivity of the neck gave discordant values when the neck of the resonator was changed from .14 to .2 cm., the resonance peaks were inverted showing that the presence of a tuned resonator increased the intensity of oscillation of the crystal.

Similar effects appeared to be present in tubes open at one end, this effect accounting for the previous irregular results. By using small tubes, more satisfactory values for wavelength were obtained.

67. Measurement of the absolute frequency of piezoelectric quartz oscillators.

S. K. KULKARNI JATKAR and H. E. WATSON, Bangalore.

The step-down crystal controlled double multivibrator described by Hull and Clapp (*Proc. Inst. of Radio Eng.*, 1929, p. 251) has been used with modifications to measure the absolute frequencies of quartz oscillators, the resulting low frequencies being measured by a synchro-clock which was timed with the laboratory standard clock. Frequencies from 300 to 1,500 could be measured directly on the synchro-clock and the multivibrator would give step-down ratios as high as 100 : 1 without a high frequency stage so that with the combination, frequencies up to 150 Kc/sec. could be measured with a degree of accuracy limited only by the constancy of the frequency under measurement. For higher frequencies the beat frequency between a harmonic of a standard oscillator and the frequency to be determined could be applied to the system and measured. In this way a 480 Kc/sec. crystal was standardised.

These measurements brought to light unexpected variations in the frequency of crystal oscillators, plating sometimes inducing a different

mode of vibration with a large frequency change. A crystal previously used for the determination of supersonic velocity and stated to oscillate at 50,014 cycles/sec. was found to have a frequency of 49,460 cycles/sec. bringing the results into agreement with those of other observers.

68. A simple recording micro-photometer.

N. B. BHATT, S. K. KULKARNI JATKAR and H. E. WATSON,
Bangalore.

A narrow beam of light from a slit with a suitable optical system passes through the plate and falls on a photoelectric cell. The resulting current is amplified by a push pull amplifier and actuates a mirror galvanometer which directs a spot of light on to the drum of a recording camera. This drum is mounted on the shaft of accurate screw which moves the plate past the source of light so that no gears are required. A magnification of 157 is obtained.

69. The general theory of the pianoforte string for Hertzian impact.

MOHINIMOHAN GHOSH, Calcutta.

A general theory of the damped pianoforte string struck by a slightly elastic hammer has already been developed by the author (*Ind. Phy. Math. Jour.*, Vol. 3, p. 15, 1932; *Ind. Sci. Cong.*, 1932), where it has been shown, that some of the previous theories are only special cases. Unfortunately, even this generalised theory is unable to explain the variation of the duration of contact with the velocity of impact (V_0), as was first noticed by Weak and Kaufmann, during their experiments with felt hammer. It may be remarked that both of them ignored this effect without attempting to explain it. The recent experiment of the writer (*Ind. Jour. Phy.*, Sept. 1932; *Ind. Sci. Cong.*, 1932) confirms the above effect beyond doubt, which therefore necessitates a further generalisation of the author's theory. This has been done in the present paper by bringing in the idea of Hertz's Impact. Thus the theory is applicable for all elastic value of the hammer.

It is found that the duration of contact (Φ) when the hammer strikes at mid-point is given by

$$\Phi = \Phi_0 + \frac{a}{V_0},$$

where (Φ_0) and (a) are constants depending on the elasticity and mass and other properties of the hammer, and also on the properties of the string. The above formula has been found to explain fairly well the variation referred to above. It may be added that all the existing theories such as of Helmholtz, Lamb, Delemer, Bhargav-Ghosh and Das are special cases of the above.

70. The application of the Hertz's theory of impact to the longitudinal vibration of a bar excited by impact.

MOHINIMOHAN GHOSH, Calcutta.

The theory of Boussinesq for the longitudinal vibration of a bar struck by a hard load has been extended by the author to the general case of an elastic load of any elastic value obeying Hooke's law of compression. In this paper the author has further extended his theory for Hertz-impact. The theoretical results obtained explain many unexplained experimental facts.

71. Surface convection and variation of temperature near a hot surface.

L. A. RAMDAS and S. L. MALURKAR, Poona.

The paper is in continuation of the previous communication entitled 'Theory of extremely high lapse-rates of temperature very near the ground'.

The nature of the turbulence near a hot surface was studied experimentally by us in detail. The space above a heated surface kept inside a smoke chamber provided with observational glass windows was illuminated by a concentrated beam of sunlight. Ammonium chloride or sulphur fumes were used. It was found that, just as in Aitken's and Lodge's experiments, there was a dark, dust-free layer above the hot surface. The heated dust-free air was found to shoot up into several tongues of ascending air; these dark columns which conveyed the heat upwards, travelled several centimetres upwards, but while their base near the hot surface was 1.5-2.5 cm. broad, their width very rapidly decreased towards the apex. The dark columns develop and move about in a random manner. The corresponding downward movements of the cold air can also be observed. These movements are associated with vortices excited by the uprush of the hot air. Several photographs of the phenomenon were taken.

72. The vertical distribution of air temperature near the ground during night.

L. A. RAMDAS and S. ATMANATHAN, Poona.

It is usually considered that nocturnal temperature inversions near the ground are due to the more rapid cooling of the ground by radiation during the night than the adjacent air and that the consequent lowering of temperature of the air near the ground is due to conduction. This is no doubt true for temperate latitudes where the intensity of solar insolation is decidedly smaller than in the tropics, and, in winter, the duration of sunshine is also less. But in India, recent measurements show that even at the epoch of minimum temperature in the cold season, the ground is at a higher temperature than the air immediately above, and that the inversion layer begins, not at the surface as is commonly assumed, but at some height above it.

Measurements over grass wet with dew show that the inversion there starts right from the surface. But on grass free from dew, the surface temperature is found to be higher than that of the air immediately above.

The data obtained by us so far have raised some interesting problems regarding the rôle of radiation from the ground and the lower layers of the atmosphere in determining the vertical distribution of temperature during clear nights. The subject is under enquiry.

73. A note on the vibrations of soap films.

L. A. RAMDAS and A. G. NARASIMHAM, Tellichery.

It is well known that a soap film shows distinct figures when different vowels or notes are sounded in its neighbourhood; the film is particularly sensitive to certain pitches and vowels and less so to others; but the patterns corresponding to each of them are more or less reproducible. When a vertical soap film showing a few interference bands at the top is projected in reflected light on a screen and vowels or notes are sounded the patterns are extremely beautiful.

The present writers recently had occasion to study photographically the vibrations of a soap film. The results obtained when the soap film

is (1) circular and vertical, (2) circular and horizontal, (3) square and vertical, and (4) square and horizontal are described.

74. A note on fog and haze in Poona during winter.

L. A. RAMDAS and S. ATMANATHAN, Poona.

The present note is based on a study of fog and haze which occur almost daily over Poona during the cold season. The variation of the intensity and thickness of fog or haze has also been studied visually and photographically from the top of the 120 feet tower of the Meteorological Office, Poona. Temperature variation with height in the first 120 feet above ground during fog or haze has also been studied from observations with an Assmann Psychrometer.

75. Note on the magnitude scale of the Hyderabad astrographic zones.

T. P. BHASKARA SHASTRI.

In the section of the astrographic catalogue published by the Nizamiah Observatory, only the diameters of star-images on the photographs are given in units of $0''.15$. For conversion of the estimated diameters into stellar magnitudes a formula $m = a - b \sqrt{d}$ has been used and the values of the constants a and b are given for each plate. This formula derived from a consideration of the magnitudes of a few bright stars in the photometry Catalogues does not represent the faint stars with accuracy. Recently some of the regions of the Catalogue have been photographed again with a number of exposures in geometric progression ranging from $1''$ to $16''$. All the images have been carefully measured and the diameters of the reference stars have been compared with the photographic magnitudes on the Harvard scale. It is found that the formula $m = a - b \sqrt{d + h}$ where a , b and h are constants, is more suitable for the plates of the Hyderabad Series and gives a better value for the magnitude of bright as well as faint stars. A similar result is obtained from a study of the photographic magnitudes of those stars in the Harvard Standard Regions that occur in the Hyderabad astrographic zones.

76. Description of the blink comparator of the Nizamiah Observatory.

T. P. BHASKARA SHASTRI.

A comparator with a blinking device attached, has been acquired for the Nizamiah Observatory, for facilitating the direct comparison of photographs of the same region taken with the astrographic telescope at different epochs. A brief description is given of the apparatus and the method of working. The instrument is used at present for the determination of proper motions of stars in the Hyderabad astrographic zones by comparing plates recently taken, with those of the original series.

77. Variation of Faraday effect with temperature, concentration and the nature of the solvent.

S. S. BHATNAGAR and A. N. KAPUR, Lahore.

The effect, of temperature and environment on the variation of the Faraday rotation of ethylene chloride, ethylene bromide, ethylene chlorobromide and other molecules containing two or more dipoles, the axes

of which may alter their positions relative to one another, has been studied and the results are discussed in the light of Ladenburg's theory.

78. On Foucault's pendulum.

G. P. KRISHNAMURTI, Madras.

The paper describes experiments carried out to test whether Foucault's pendulum, designed to demonstrate the rotation of the earth, shows the effect at places of low latitude like Madras ($13^{\circ} 4' \text{ N.}$), as it does at places of high latitudes, where the effect, viz. the turning of the plane of oscillation of the pendulum in the clockwise direction as looked at from above, is perceptible in a few swings. The experiments show that a pendulum consisting of a spherical bob weighing 15 lb. and hung from a point in the ceiling by a thin steel wire 15 feet long shows the effect perceptibly in half an hour, when the plane of oscillation is found to have turned clockwise; and the angle of rotation per hour is of the order given by the sine law $15^{\circ} \sin 13^{\circ} 4'$ (latitude of Madras). The pendulum continues to oscillate for about six hours.

79. Viscosity balance.

S. M. A. KHAN, Hyderabad, Deccan.

Starting from Poiseuille's Law for the flow of liquids in capillary tubes, a simple relation is established between the Viscosities and the corresponding values of the Surface Tensions of two liquids. On the experimental side the method dispenses with the use of a stop-watch or a balance: the measurement of the radius of the capillary tube and its length are also done away with. All the necessary measurements are expressed in terms of the Viscosity of some standard liquid, such as pure water at constant temperature. The method may be applied not only to investigate the variation of Viscosity with temperature, but also at different concentrations of various salt solutions and mixtures.

In the experiment the drops of two different liquids through two identical capillary tubes are observed at the same time. The manometric pressure is self-adjustable, and at a certain stage it helps the drops through the two capillary tubes to fall simultaneously for a short time. Results depend entirely on the accurate measurement of the pressure heights.

80. Areas of hydrogen absorption markings and calcium prominences in the first half of 1931.

G. V. KRISHNASWAMI.

The Kodaikanal Observatory publishes semi-annual summaries of observations on K_{23} prominences and H_{α} absorption markings. In bulletin No. 94 embodying the observations for the first half of 1931 it is stated that 'the distribution of (prominence) activity is very similar in both the northern and southern hemispheres (and) the activity now increases from the equator up to latitude 45° and is very small beyond 55° , and that 'in contrast to the distribution of prominences at the limb, there is a minimum activity near 30° , particularly marked in the southern hemisphere (as exhibited by prominences projected on the disc as absorption markings)'. The paper attempts to seek the causes for the contrast.

The charts and plates for the period are examined for any peculiarities. A new distribution of the mean daily areas of prominences weighted according to their density in the scale 1 to 5 is arrived at which is found to conform fairly to the distribution of the areas of absorption markings.

81. The variation in area of hydrogen absorption markings with longitude from the central meridian.

G. V. KRISHNASWAMI.

In the *Kodaikanal Observatory Bulletin* No. 96, the section of a prominence perpendicular to its length is assumed to be a triangle. A consideration of the forces at work in the formation of a quiescent prominence, whose projection on the disc is a H_{α} marking persisting for several days and the observations of experienced astronomers show that a parabolic section is a more probable one.

On this assumption, the ratio of a H_{α} marking lying longitudinally on the surface of the Sun is compared with its area when at the central meridian. The ratio of the height of the prominence to its breadth that best fits the values in Table I of the bulletin is derived. It is found that there are two solutions, viz. 1.6 and .3 nearly. The latter gives a very small value for the height of the prominence, about 5". This is explained by the fact that it is only this height that is effective in absorption (*K.O.B.*, 89). But the former value fairly agrees with that deduced in *K.O.B.* 96, and is not admissible in the large number of cases where these absorption markings are fringed with bright margins corresponding to the bright lower parts of the prominence (*K.O.B.*, 63).

A few other points regarding the lengths and areas of the markings and the western preponderance of ratios are explained.

82. The relation between metallic prominences and disc phenomena.

G. V. KRISHNASWAMI.

The results of this paper are based on the records and spectroheliograms of the Kodaikanal Observatory for the years 1929-1931, and the first half of 1932 supplemented by the records of the Worthing Observatory, England, for the years 1929-1931 very kindly supplied by Mr. A. M. Newbegin. 138 metallic prominences observed at Kodaikanal and 207 observed at Worthing have been examined for any related disc-phenomena such as spots, faculae, calcium, and hydrogen bright flocculi. The results of the investigation are set forth.

83. Tables for comparing standard deviations of small samples.

P. C. MAHALANOBIS, Calcutta.

The classical theory of errors is strictly applicable only to large samples. To test the significance of differences in mean values or variances based on small sample, it is necessary to use the theory developed in recent times by 'Student', R. A. Fisher and others. Fisher has given two tables for the 5% and 1% values of a certain statistic Z given by

$$Z = \frac{1}{2} \log_e \left(\frac{s_1^2}{s_2^2} \right)$$

where s_1 and s_2 are the two variances (based on two samples of size n_1 and n_2 respectively) to be compared. In order to apply Fisher's z -tables it is necessary to use natural logarithms.

In this paper new tables have been given with the help of which it will be possible to test the significance of differences of variances or standard deviations directly from the ratio of the observed variances or the ratio of observed standard deviations.

84. Tables for the application of Neyman and Pearson's L tests for judging the significance of observed divergence in mean values and variabilities of K samples.

P. C. MAHALANOBIS, Calcutta.

A number of K samples may differ in (i) population mean values, or (ii) population variabilities, or (iii) a combination of both. Neyman and Pearson have recently developed certain tests which may be called L_1 , L_2 , and L_0 tests respectively which would distinguish between the above three cases. The calculation of observed L values is simple and straightforward, but the estimation of expected values of L (on a 5% or 1% level of significance) is extremely difficult as it involves for each pair of values of n and K (the size and number of samples) work with ten different Gamma functions with fractional parameters. The present tables will cover the range for $n=2, 3, 4, 5, 10, 15, 20, 30, 40, 50$, and ∞ , and $K=2, 4, 5, 10, 20, 25, 50$, and ∞ .

85. A study of the correlation between the height of the Brahmini at Jenapore and the rainfall in the catchment area.

P. C. MAHALANOBIS, Calcutta.

It was believed that the level of the river bed of the Brahmini changed suddenly after a great flood in 1920. On this view future floods were expected to attain a much greater height than in the past. A careful study of the rainfall and river gauge records does not corroborate the above theory. It has been shown that the height of the river can be reconstructed with considerable accuracy from the precipitation in the catchment area, and the apparent increase in height after 1920 can be traced to a period of increasing rainfall. On this view there is no reason to apprehend that floods will be appreciably more severe or more frequent in the future.

86. A study of the areal distribution of rainfall during rainstorms in the Mahanadi catchment.

P. C. MAHALANOBIS and ANIL CHANDRA NAG, Calcutta.

About 40 storms (year maximum for the period 1891-1929) have been analysed in great detail for periods of 3, 4, and 5 consecutive days. The average and limiting intensities of precipitation have been calculated separately for five sections as well as the whole of the Mahanadi catchment. It has been found that the intensity-area curves can be graduated fairly well by third order parabolas.

87. A study of the correlation between the height of the Mahanadi at Naraj and the rainfall in the Mahanadi catchment.

P. C. MAHALANOBIS and NISTARAN CHAKRAVARTI, Calcutta.

In this paper a detailed study has been made of the correlation between river height and precipitation. Several formulæ have been constructed with the help of multiple correlation coefficients for forecasting the height of the river at Naraj.

88. A study of the intensity of floods in the Mahanadi for the period 1868-1929.

P. C. MAHALANOBIS and K. C. BASAK, Calcutta.

In this paper an attempt has been made to construct a numerical scale for flood classification from three different standpoints :—(i) amount of discharge across the river at Naraj, (ii) height of the river, and (iii) damage caused in the Orissa delta. It has been found that there is satisfactory convergence of the evidence from different directions.

89. A study of the seasonal fluctuations in the height of the Orissa rivers.

P. C. MAHALANOBIS and R. N. SEN, Calcutta.

In this paper a detailed study has been made of the change in the average height of the river with the advance of the monsoon for the rivers Mahanadi, the Brahmini, and the Baitarani. It has been found possible to graduate the data with simple parabolic curves.

90. A study of the precipitation and the percentage run-off in the Mahanadi.

P. C. MAHALANOBIS and NISTARAN CHAKRAVARTI, Calcutta.

The data for the period 1868-1929 have been analysed statistically in this paper, and it has been found that the percentage run-off steadily diminishes and appears to approach a limiting value with increasing intensities of the rainstorms.

91. A study of the correlation of the height of the Mahanadi at Sambalpur and at Naraj.

P. C. MAHALANOBIS and P. R. RAY, Calcutta.

It has been found that a very close correlation (of the order of 0.8 and 0.9) exists between the heights of the gauges at Sambalpur and Naraj situated at a distance of about 180 miles. An attempt has been made to estimate the lag of the maximum height of the flood by studying the variation in the coefficient of correlation with time. A provisional estimate has also been made of the average velocity of the maximum flood height.

92. A study of the intensity of floods in the Brahmini for the period 1868-1929.

P. C. MAHALANOBIS and S. S. BOSE, Calcutta.

This is an attempt to classify floods that occurred in the River Brahmini during the period 1868-1929. The classification was based on the simultaneous considerations of two standards, viz. amount of damage and the level of the river at Jenapur. The detailed analysis showed that of 40 reported cases of flood, as many as 23 occurred in August and 14 in July. Again, out of the 25 cases in which the intensity of the flood was of some consequence, as many as 13 occurred in August and 9 in July.

93. On space determinants.

PANCHANON BHATTACHARYYA.

The elements of a square determinant of order two lie on the four corners of a square. Analogous construction of a cubic determinant of order two by placing eight elements on the eight corners or vertices of a cube. Generalisation of the idea into a space of r dimension. An r space determinant of any order n has n^r elements. Through each element there pass r types of rows, and also r types of faces, each of $(r-1)$ dimension, respectively normal to the directions of the r rows. Co-factor of any element is obtained by erasing r types of faces passing through the element.

Properties of square determinants are all deducible from the general properties of space determinants. The product of two space determinants of the same order equal to another determinant of the same order but of higher space dimensions. The deduction of the existing theorem for multiplication of two square determinants. Space matrices. There are r -types of rows of different lengths. Expansion in terms of the elements of the longest face normal to the shortest row.

Algebraical and geometrical applications. Generalisations of all the existing theorems of Jacobi, Laplace and others with regard to determinants. Generalisations of the properties of certain well-known curves such as Jacobians, Hessians, Steinerians, Cayleyans, etc.

94. Orbit and the conditions of periodic orbit.

K. KHASTAGIR.

In this paper, the orbit and the conditions of periodic orbit for the value of

$$V = \left(-\frac{\mu}{r} + \frac{\lambda}{r^2} \cos \theta \right)$$

have been found.

95. On the infinite series of integrals involving Sturm-Liouville Eigenfunctions.

M. RAZIUDDIN SIDDIQI.

In a previous paper [*Math. Zs.*, 35 (1931)], it has been proved by the writer that the series

$$\sum_n \frac{n \left| a_{k,j}^{(n)} \right|}{k_1^2 \dots k_r^2 j_1^3 \dots j_s^3},$$

where

$$a_{k,j}^{(n)} = j_1 j_2 \dots j_s \int_0^\pi \sin k_1 x \dots \sin k_r x \cos j_1 x \dots \cos j_s x \sin nx \, dx,$$

is uniformly convergent for all k_r, j_s .

It is natural to ask, therefore, whether a similar property is possessed by Eigenfunctions other than the sine and cosine functions. In the present paper, the following general theorems are proved:—

If λ_n ($n=1, 2, \dots$) are the Eigenvalues and $\phi_n(x)$ are the Eigenfunctions of the Sturm-Liouville differential equation, and if we define

$$a_{j,k}^{(n)} = \int_0^\pi \phi_j(x) \phi_k(x) \phi_n(x) dx,$$

$$b_{k,j}^{(n)} = \int_0^\pi \phi_k(x) \frac{d\phi_j}{dx} \phi_n(x) dx,$$

then the series

$$\sum_{n=1}^{\infty} \frac{\sqrt{\lambda_n} |a_{j,k}^{(n)}|}{\lambda_j \lambda_k} \text{ and } \sum_{n=1}^{\infty} \frac{\sqrt{\lambda_n} |b_{k,j}^{(n)}|}{\lambda_k \lambda_j^{\frac{1}{2}}}$$

converge uniformly for all $j, k \geq 1$.

These theorems are important in the theory of higher integral equations and partial differential equations, as has been shown by the writer in two papers communicated to the *Bull. Calcutta Math. Soc.*, 24 (1932) and the *Proc. London Math. Soc.*, respectively.

96. The absolute of the in- and the ex-circles. Part III.

M. BHIMASENA RAO and M. VENKATARAMA IYER.

The Part I of the above paper was read before the Seventh Conference of the *Indian Mathematical Society*, and Part II before the Nineteenth Annual Meeting of the *Indian Science Congress*.

Professor Lachlan has shown that the radius of the circle

$$ax_1 + bx_2 + cx_3 + dx_4 = 0$$

will be given by

$$\begin{vmatrix} a_{1,1} & a_{1,2} & a_{1,3} & a_{1,4} & a \\ a_{2,1} & a_{2,2} & a_{2,3} & a_{2,4} & b \\ a_{3,1} & a_{3,2} & a_{3,3} & a_{3,4} & c \\ a_{4,1} & a_{4,2} & a_{4,3} & a_{4,4} & d \\ a & b & c & d & M \tan^2 \rho \end{vmatrix} = 0$$

where

$$M = -\frac{2}{k} (a+b+c+d)^2.$$

If Δ is the minor of $M \tan^2 \rho$ in the above determinant,

$$2 \tan^2 \rho (a+b+c+d)^2 \cdot \Delta$$

= the same determinant with 0 in the place of $M \tan^2 \rho$. Substituting the values of $a_1, 1, a_1, 2$, etc. from the absolute, we get

$$\tan^2 \rho (a+b+c+d)^2 = \frac{1}{2} \phi(a, b, c, d),$$

where

$$\begin{aligned} \phi(a, b, c, d) = & \left[2a^2 \tan^2 r_1 + 2b^2 \tan^2 r_2 + 2c^2 \tan^2 r_3 + 2d^2 \tan^2 r_4 \right. \\ & \left. + 2bc \tan r_2 \tan r_3 \left(\frac{\lambda_1}{\lambda_4} + \frac{\lambda_4}{\lambda_1} \right) - 2ad \tan r_1 \tan r_4 \left(\frac{\lambda_2}{\lambda_3} + \frac{\lambda_3}{\lambda_2} \right) \right] \end{aligned}$$

$$\begin{aligned}
& + 2ca \tan r_3 \tan r_1 \left(\frac{\lambda_2}{\lambda_4} + \frac{\lambda_4}{\lambda_2} \right) - 2bd \tan r_2 \tan r_4 \left(\frac{\lambda_3}{\lambda_1} + \frac{\lambda_1}{\lambda_3} \right) \\
& + 2ab \tan r_1 \tan r_2 \left(\frac{\lambda_3}{\lambda_4} + \frac{\lambda_4}{\lambda_3} \right) - 2cd \tan r_3 \tan r_4 \left(\frac{\lambda_1}{\lambda_2} + \frac{\lambda_2}{\lambda_1} \right) \Big] \\
& \times 2 (\lambda_2 \lambda_3 - \lambda_1 \lambda_4) (\lambda_3 \lambda_1 - \lambda_2 \lambda_4) (\lambda_1 \lambda_2 - \lambda_3 \lambda_4) \\
& \times \cot^2 r_1 \cot^2 r_2 \cot^2 r_3 \cot^2 r_4.
\end{aligned}$$

In the case of the Hart's circle, this assumes the form,

$$\begin{aligned}
& (bc \tan r_2 \tan r_3 + ad \tan r_1 \tan r_4) (ca \tan r_3 \tan r_1 + bd \tan r_2 \tan r_4) \\
& (ab \tan r_1 \tan r_2 + cd \tan r_3 \tan r_4) \div (abcd \tan r_1 \tan r_2 \tan r_3 \tan r_4).
\end{aligned}$$

97. On the summability of Fourier series by means of Arithmetic.

B. N. PRASAD.

Taking $f(x)$ to be a function periodic and integrable in the sense of Lebesgue and

$$2\phi(t) = f(x+2t) + f(x-2t) - 2f(x); \quad \Phi(t) = \int_0^t \phi(u) du,$$

in the first part of this paper a general method has been developed by which all the known criteria of Fejér, Lebesgue, etc. for the summability $(C, 1)$ of Fourier series, together with several new ones, can be obtained in a natural, connected manner.

Observing that when the integral

$$\int_0^t \frac{\phi(t)}{t} dt \tag{A}$$

exists as a non-absolutely convergent integral,

$$\lim_{t \rightarrow 0} \frac{\Phi(t)}{t}$$

is necessarily zero, but not *vice-versa*, we know from the investigations of Hahn that the condition of the existence of

$$\lim_{t \rightarrow 0} \frac{\Phi(t)}{t}$$

as zero is not sufficient for the summability $(C, 1)$ of Fourier series. The object of the second part of the paper is to take up the more delicate investigations as to the summability or non-summability of Fourier series when the integral (A) exists. It has been shown that even the existence of the integral (A) is not a sufficient condition for the summability $(C, 1)$ of Fourier series, and this covers the case considered by Hahn.

98. On a generalised formulation of Trouton's law.

SATYENDRA RAY, Lucknow.

In a paper submitted to the U.P. Academy of Sciences, on 'Parallel possible solutions of the Virial of Intermolecular Forces of a gas and

Cauchy's Fundamental Stress Equations for a solid', it has been shown that a variation of force according to an exponential law is capable of giving a gradual transition from a huge intrinsic negative pressure inside a solid or liquid to the small positive vapour pressure at the surface.

This relation is applied to the special case of a drop of a liquid evaporating from its surface. The laws assumed are for the liquid :—

$$X_l = -X_{l_0} (1 - ae^{k_1 x})$$

and, for the gas :—

$$X_g = +X_{g_0} (1 - be^{-k_2 x}).$$

It is shown this leads to the result

$$k_2/k_1 = \log (mL/RT).$$

At the critical temperature

$$k_1 = k_2$$

and

$$X_{l_0} = 0 = X_{g_0}.$$

This generalisation therefore removes the difficulty pointed out by Saha and Srivastava in Trouton's Law (*Text-Book of Heat*, p. 223) and makes the result valid up to the critical temperature.

99. On the production of (1) the Wolf Note, and of (2) Circular and (3) Torsional vibrations in a Melde's string.

SATYENDRA RAY, Lucknow.

In *Nature* of February, 1932, the production of a periodic vibration of Melde's string by a continuous force, transverse or longitudinal, has been reported by the present writer. The Wolf Note, or periodic alternation between the fundamental and its octave, (2) Circularly polarised vibration, and (3) Torsional vibration has also been obtained with Melde's string with such excitation.

100. On the variation of the reverberation period in architectural acoustics with pitch.

SATYENDRA RAY, Lucknow.

In continuation of the paper before U.P. Academy of Sciences on the independence of the reverberation period from the volume, it is shown mathematically, that the reverberation period decreases with increase of pitch, and explains the physiological perception of audition improving with pitch.

101. On the variation of potential with depth of a liquid.

SATYENDRA RAY, Lucknow.

A copper calorimeter was placed on a non-conducting stand, and a copper wire soldered to the bottom was used as a terminal of a galvanic element. The other terminal was a copper wire soldered to a copper rod placed along the axis of the calorimeter, without touching the bottom. The fluid employed was distilled water. It was found, when the rod was gradually raised the potential, as measured by a Crompton Potentiometer, was fairly constant in the bulk of the liquid, a variation appearing near the bottom as also near the surface. It is believed adsorption and surface tension have to do with these two variations. The voltage was of the order of 50 millivolts.

Section of Chemistry.

President :—DR. P. NEOGI, M.A., PH.D., I.E.S.

Presidential Address.

OPTICAL ISOMERISM OF CO-ORDINATED INORGANIC COMPOUNDS.

I tender my cordial thanks to the authorities of the Indian Science Congress for the honour they have done me in electing me President of this section this year, and would respectfully beseech the co-operation of all members of the Congress in making the proceedings of this session successful and full of solid achievements. The Congress is completing the twentieth year of its existence this year, and those who, like myself, attended its first session in the rooms of the Asiatic Society of Bengal at Calcutta twenty years ago, are struck with the enormous expansion of its activities and specially of its Chemistry Section for which, if you would permit me, I would claim the title of being the busiest of all the sections of the Congress. Only eight papers on chemical subjects were read at the first session whilst the number of papers read in the Chemistry Section for several years past fluctuates in the neighbourhood of two hundred and has this year reached the record total of two hundred and fifty. It would therefore be a matter of great interest to analyse the causes which have led to this remarkable increase in the output of original work, specially in Chemistry, throughout the length and breadth of India within the last twenty years. Thirty years ago when we were college students, the college which I have the honour to belong to, was the only one in India from which Sir (then Dr.) P. C. Rây used to contribute his papers to current chemical literature, and I well remember that almost every paper which he published in the Journal of the London Chemical Society was commented upon by the newspapers of the country as a proof that Indians were fully capable of doing original work in chemistry. My countrymen have just celebrated the seventieth birthday of one who, along with Sir Alexander Pedler who also belonged to my college and Dr. Richardson of the old Benares Hindu College, shares the glory of being pioneers of chemical research in India, and I hope you will join me as an old pupil of Sir P. C. Rây and a representative of this section in wishing him still a long lease of life which has so long been devoted to the furtherance of the cause of chemistry both in its pure and applied aspects.

I was speaking of the research papers of Sir P. C. Rây being regarded, to use a common chemical phraseology, as 'chemical curiosities' in those early days, but thirty years have

witnessed the performance of a miracle and the spirit of scientific work has by this time become so widespread in our colleges and universities that only the most outstanding discoveries of our scientists like that of Raman rays at all attract the attention of the Indian public at the present day. Nevertheless it is very true, as evidenced by the reproduction of the work of our chemists in the Annual Reports of the Progress of Chemistry issued by the London Chemical Society as well as in textbooks on chemistry, that original work of very substantial value is being turned out in almost all Indian universities and colleges possessing post-graduate departments. The principal causes which, to my mind, have contributed to this happy result are, amongst others, the following :—

(1) establishment of post-graduate departments in the older Universities of Calcutta, Bombay, Madras, Allahabad, and the Punjab thus making them teaching universities so far as the highest departments of science subjects are concerned,

(2) establishment of fully-equipped teaching universities, mainly as a result of the recommendations of the Sadler Commission in various parts of India such as at Benares, Aligarh, Lucknow, Patna, Rangoon, Nagpur, Agra, Dacca, Waltair, Chidambaram, and in the Native States of Hyderabad and Mysore,

(3) expansion and consolidation of purely research institutions like the Indian Institute of Science at Bangalore and establishment of technological departments of Universities like those at Calcutta and Benares and also of technological institutes at Cawnpore and some other places,

(4) establishment of agricultural, industrial and other scientific departments by provincial governments and the larger native states,

(5) institution of the M.Sc. degree in science subjects in many universities as a research-cum-examination degree in the place of the old practice of conferring the degree on the merits of examinations only with the result that our young men are receiving their training in scientific research even at the M.Sc. stage,

(6) institution of the Doctor's degree for research in many Indian Universities and establishment of research scholarships by many Universities, Institutes, and Provincial Governments,

(7) last, but not least, the establishment of the Indian Science Congress itself which has served these twenty years to bring together annually individual workers in different branches of science from all parts of the Indian Continent who are thus relieved of their isolation and enabled to compare notes with each other's work and who in their turn inspire the youth of the country with a desire to emulate the work of their elders.

It is neither the place nor the time to deal with these items individually in any detail and I shall therefore have to remain

satisfied with a mere enunciation of the causes, which, I have ventured to suggest, have led to the rapid increase of original work throughout the country. It is a happy augury for the future well-being of our youths that teaching universities with fully-equipped science laboratories are springing up almost like mushroom-growth in all parts of the country, and the huge benefactions of our illustrious countrymen such as the late Mr. Jamsedji Tata and his sons of Bombay, Sir Rash Behary Ghose, and Sir Tarak Nath Palit of Bengal, Sir Annamalai Chetty of Madras, Rao Bahadur D. Lachminarayan of the Central Provinces and others for the promotion of university and science teaching and research show that our countrymen have come to realise that the industrial salvation of the country largely depended on the expansion of science teaching in its highest standards. And as original investigation has nowadays come to be regarded everywhere as a hand-maid of teaching, it is no wonder that rapid expansion of the former has taken place in all parts of India.

In this connection I would like to refer particularly to one individual who is the invariable co-worker of the teacher in its original investigation, and in fact, if I venture to express myself, is the mainstay of the prevailing system of research work in all universities, viz. the research student. A mere glance at the agenda, say, of the Chemistry section, will convince anyone that the research student, scholar or assistant is omnipresent, as, barring half a dozen, all papers are the results of the joint labours of the teacher and the research student. This is happening every year, which means that about two hundred or more students are being trained every year in the technicalities of chemical research by their active participation in the research work of the teacher. This is the path trodden by the new aspirant for fame for original work in every European country and elsewhere. I would therefore respectfully request the authorities of all Indian Universities, who have not yet instituted the M.Sc. degree on a research basis in addition to examination, to do so without further delay. In fact, I can bear testimony from personal knowledge of my own University that the M.Sc. thesis student has succeeded in making the atmosphere of our post-graduate laboratories heavily surcharged with keen enthusiasm for original work and I believe the same is true of every university which has already adopted the system of giving the same degree on the combined test of examination and research. I shall go still further and plead with all the earnestness I can command for the establishment in our universities of an intermediate Doctor's degree for original work after the M.Sc. stage which will be conferred on those who will continue to devote themselves to such work successfully though still assisted by the teacher. In many British and European Universities the Ph.D. degree

is given to passed M.Sc.s. who can show a record of original work though still assisted by their teacher, the D.Sc. degree being given for independent work. A beginning in this direction has, I understand, been made at the Aligarh University, and I would venture to recommend the adoption of the same system by all our Indian Universities.

At the same time a liberal system of research scholarships, without which I am afraid many of our students who generally come from the middle strata of our society would be unable to stay very long at the university for post-M.Sc. degrees, should be introduced. It is a common mistake to forget the research scholar when planning a laboratory and its staff. He should certainly be thought of whilst the question of the staff is considered in connection with a laboratory. A good working rule would be to set apart twenty to twenty-five per cent. of the amount available for the staff for establishing research scholarships. If necessary, even a professorship of Rs. 500 per mensem should be sacrificed and converted into ten research studentships of Rs. 50 each, or better, five of Rs. 100 each. That will certainly be money better spent. A fifty to hundred rupee stipend and a prospective Doctor's degree will keep the most brilliant of our M.Sc.s. engaged in research work for three or more years in any university. Happily the system already prevails in many places notably at the Indian Institute of Science at Bangalore, and in fact the advent of the research student at the M.Sc. stage and later explains in a great measure the recent remarkable increase in original work in all parts of the country.

With these preliminary observations on a question, the right solution of which, I venture to suggest, affects all sections of this Congress, I propose to pass on to the scientific portion of my address. It is difficult to choose a scientific subject for a Presidential Address which will please everybody at one and the same time, viz. the expert and the lay scientific public. A friend of mine, when asked about his enjoyment of the Presidential Addresses delivered in a particular session of this Congress summarised his impressions of the addresses delivered by the Presidents of the Physics and Chemistry sections in the following words 'I went to listen to the address of the President of the Physics section and found that it was all Mathematics, and then on coming to the Chemistry section I found that it was all Physics'. Whilst sympathising with him in his disappointment I am to point out that this particular gentleman was unconsciously laying emphasis on the ultimate correlation of all sciences, which seek to elucidate the secrets of nature's magnificent creation in all its diverse aspects and also incidentally to utilise the results of such search for pure knowledge to the production of commodities the use of which goes to increase human happiness, comfort and civilisation. Nevertheless, the difficulty

for the President is still there all the same. I have therefore attempted to deal with a subject which is certainly devoid of Mathematics and possibly of Physics, and is also expected to prove of interest to the two neighbourly, though not very friendly, members of the same joint family, viz. the organic and the inorganic chemist. The subject I intend to discuss is 'optical isomerism of co-ordinated inorganic compounds'. The first half of the title of the subject is organic but the last half unfortunately inorganic. It would be interesting to note, as it is my intention to emphasise, how the conceptions which arose entirely out of the study of organic chemistry have been successfully grafted to inorganic compounds which fact proves, if proof was indeed needed, that there really exists no barrier between the two sister branches of chemistry, as is sometimes unfortunately apprehended by some. In these days of extreme specialisation the combination of the knowledge of inorganic and organic chemistry is regarded in many quarters as an anomaly and anachronism, but I venture to submit that Werner, the father of inorganic stereo-chemistry, was able to develop almost a new branch of Chemistry on account of his encyclopædic knowledge of both the branches of the Science.

It is our desire to narrate the story of optical isomerism as applicable to the case of co-ordinated inorganic compounds, keeping however all the while the parallelism of organic compounds in view. It is to be noted at the outset that orthodox organic conceptions with respect to optical isomerism have received striking confirmations in many particulars, whilst in others striking deviations have been observed. It is the purpose of this paper to bring out these resemblances as well as the differences into prominence so that the future chemist, inorganic as well as organic, will be able to fill up gaps wherever they exist and explain facts hitherto remaining unexplained.

SPACE REPRESENTATION OF ELEMENTS OTHER THAN CARBON AND OF CO-ORDINATED COMPLEXES.

Since the discovery of optical isomerism in tartaric and lactic acids hundreds of naturally occurring compounds have been found to be optically active. Nature appears to be a master-builder of active compounds, as artificial products prepared by the chemist are almost invariably racemic which subsequently are resolved into active modifications by special methods. Optical isomerism was, as is well known, explained by Le Bel and Van't Hoff in 1874 on the conception of the tetrahedral space arrangement of carbon linkages. It is remarkable that within a short period of half a century the implications of this theory have been extended far beyond the limits which the authors of the theory could ever venture to visualise. It has led to the actual discovery of numerous

classes of optically active compounds of elements other than carbon such as nitrogen, sulphur, selenium, phosphorus, arsenic, boron, tin, lead, silicon, and even inorganic co-ordinated compounds containing cobalt, chromium, beryllium, platinum, ruthenium, rhodium, iridium, etc. A department of chemistry dealing with optical and geometrical isomerism of compounds of not only carbon but also of a large number of elements belonging to the different groups of the periodic Classification has arisen in which the isomerism has been explained on the newer conception of the arrangement of the atoms in space.

It is only to be expected that the tetrahedron as originally postulated to represent the tetravalent carbon atom in space may not represent the space arrangement of other elements. A short résumé of the space representations of elements other than carbon would therefore be a useful prelude to the understanding of the space representation of co-ordinated complexes.

Taking the case of pentavalent nitrogen, all manners of space formulæ other than the tetrahedron were pressed into service for over half a century on the mistaken supposition that all its five valencies were similarly situated. Van't Hoff himself in 1878 postulated a cubic representation for pentavalent nitrogen. In 1890 Willgerodt¹ proposed a double tetrahedron formula and in 1908 Bischoff² a pyramid formula. Numerous experiments to determine the possible isomers of the type NA_3BX , NA_2BCX , and NABCDX , theoretically deducible from the three formulæ and resolvable into optical isomers have shown that none of these configurations really conforms to experimental facts. Meisenheimer showed that in substituted organic ammonium compounds the fifth bond is differently situated from the other four. A single tetrahedron formula has been postulated, and the following table shows that the deductions of this formula alone regarding the number of isomers of substituted ammonium compounds, resolvable as well as non-resolvable, are corroborated by experiments, whilst those deducible from the other three are not³ :—

	NA_3BX	NA_2BCX	NABCDX
Van't Hoff's Cube ..	2	3*	4†
Willgerodt's double tetrahedron ..	2	3*	4†
Bischoff's Pyramid ..	<i>nil.</i>	2*	3†
Single tetrahedron ..	<i>nil.</i>	<i>nil.</i>	1†
Experiment ..	<i>nil.</i>	<i>nil.</i>	1†

This fact of the non-equivalence of the fifth bond of nitrogen which binds an ionisable radical has a bearing on the space

¹ Willgerodt, *J. Prakt. Chem.*, 1890, 41, 291.

² Bischoff, *Ber.*, 1908, 23, 1197.

³ Neogi, *Journ. Amer. Chem. Soc.*, 1919, 41, 622.

* One divisible into optical isomers.

† Each divisible into optical isomers.

representation of co-ordinated inorganic compounds in which the ionisable radical outside the co-ordination complex $[\text{Coen}_3]\text{Cl}_3$ has, as in the case of the ammonium compounds, also no influence on the optical isomerism of the compound, which is entirely dependent on the metallic complex.

Other elements of group V, like phosphorus and arsenic, which yield optically active compounds would also possess a single tetrahedron space representation, the fifth bond being outside it.

As regards trivalent elements, those which like nitrogen pass to pentavalency, have a plane configuration which may also assume an 'in-tetrahedron' formula passing to the complete regular tetrahedron on assuming pentavalency.¹ Other trivalent elements might possess plane or tetrahedral representation in which they occupy one summit according as they do or do not yield stereo-isomers.

Silicon, tin, and lead of Group IV would also possess a tetrahedral structure similar to that of carbon which would explain the optical isomerism of compounds containing those elements.

It is to be noted that according to Lewis Langmuir's Octet theory of Valency, nitrogen, phosphorus, sulphur, etc. have a tetrahedral grouping of the electrons whenever their atoms are quadricovalent.

Regarding the space representation of elements of Group VI such as sulphur and selenium, optical isomerism is met with in compounds containing the elements in the tetravalent condition. Hence a single tetrahedral formula identical with the carbon representation will explain their optical isomerism. Optically active tellurium compounds have not been prepared in spite of the attempts of Lederer, but if such compounds are actually obtained in future, though possibilities are not bright as shown by Vernon, a single tetrahedron formula will explain their activity also. Chromium belonging to this group does not yield simple active organic derivatives but forms complex co-ordinated compounds which, as is noted below, possess an octahedral instead of a tetrahedral structure.

We now pass on to the structure of co-ordinated complex compounds. As already stated whilst dealing with the substituted organic ammonium compounds, the ionisable group outside the co-ordination does not affect the number of their optical isomers and is so left out of consideration whilst assigning space formulæ to these compounds. After having postulated his well-known theory of valency, Werner extended the conception of space representation, which has hitherto been entirely confined to organic compounds, to these co-ordinated inorganic

¹ Neogi (*loc. cit.*)

compounds. He and his co-workers soon discovered the following experimental facts relating to their isomerism :—

(1) A co-ordination complex usually contains six monovalent groups (smaller and higher numbers are not unknown) round the central metal atom,

(2) Compounds containing complex of the type $[MA_6]$ do not exist as isomers,

(3) Compounds containing complex of the type $[MA_5B]$ also do not exist as isomers,

(4) Cis- and trans-isomerism exists in compounds containing complex of the type $[MA_4B_2]$ or $[MA_4BC]$,

(5) In cis-compounds containing complex of the type $[MA_4B_2]$ or $[MA_4BC]$ if A_4 be substituted by two radicals, acidic like oxalato, etc., or basic like ethylenediamine, dipyridyl, etc., each occupying two co-ordination positions in the complex, the compound would exhibit optical isomerism,

(6) Further, if in compounds containing complex of the type $[MA_6]$, A_6 be substituted by three radicals like oxalato, ethylenediamine, dipyridyl, etc., each occupying a double co-ordination position in the complex, such complex would also exhibit optical isomerism.

These experimental results could only be explained, as postulated by Werner, by representing the central atom at the centre of a regular octahedron with the six groups situated at its apices. As a matter of fact, X-ray examination shows that in crystals of complex salts the co-ordination groups are arranged round the central atom at the six corners of an octahedron. The first cis-trans inorganic compounds were isolated by Werner and Humphrey in 1901 and the first optical isomers by Werner and Kling in 1911. About fifty series of active inorganic compounds have since been prepared thus establishing the validity of the octahedral space representation of hexa-co-ordinated compounds. Quadri-co-ordinated complexes have mostly been given plane configurations, as they do not generally yield optical isomers.

In this paper we are dealing with these co-ordinated inorganic compounds only and not with the active compounds containing nitrogen, sulphur, selenium, silicon, etc. joined with organic radicals which are generally classed as organic compounds.

ELEMENTS WHICH HAVE YIELDED ACTIVE CO-ORDINATED COMPOUNDS.

The first active co-ordinated inorganic compounds contained cobalt as the central element. Soon Werner was able to isolate active complex compounds containing other elements. The

NOTE.—M=central metal atom; A, B, C=monovalent groups; en=ethylenediamine; C_2O_4 =oxalato group.

elements which have yielded active co-ordinated compounds are the following :—

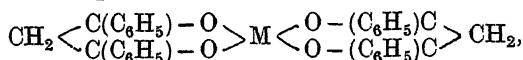
Group VI	Cr.
Group VIII	Fe, Co, Ni,
			Ru, Rd, Pd, Ir, Pt.

It is very remarkable that heavy metals of the eighth or transitional group readily yield these compounds, as these elements form amines which are stable enough to withstand decomposition by even strong mineral acids. Ephraim¹ has shown that the stability of metal-ammines is dependent on the atomic volume of the central element and that elements the atomic volumes of which are greater than fourteen do not ordinarily yield stable hexammino-compounds at ordinary temperatures.

Besides these, co-ordinated compounds of the following elements have also recently been resolved :—

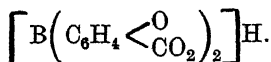
Group I	Cu
Group II	Be, Zn,
Group III	B, Al,
Group V	As.

As regards the co-ordinated compounds of beryllium, copper and zinc with benzoyl pyruvic acid Mills and Gotts have shown that they contained the metal in the place of carbon in combining two rings at right angles to each other. Their constitution is represented by

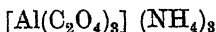


M representing beryllium, copper or zinc.² Burgess and Lowry have been able to resolve beryllium benzoyl camphor.³

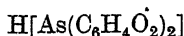
Regarding boron, Böeseken and Meulenhoff⁴ have been able to prepare a compound of salicylic and boric acids in the active condition to which they have assigned the co-ordinated formula



Wöhl⁵ has been able to prepare optically active aluminium compounds by resolving ammonium aluminium oxalate.



A co-ordinated arsenic compound tricatecholarsenic acid of the formula



¹ Ephraim, *Ber.*, 1912, 45, 1322.

² Mills and Gotts, *Trans. Chem. Soc.*, 1926, 3121.

³ Burgess and Lowry, *Trans. Chem. Soc.*, 1924, 125, 2081.

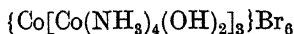
⁴ Böeseken and Meulenhoff, *Proc. K. Akad. Wetensch.*, 1924, 27, 174.

⁵ Wöhl, *Ber.*, 1927, 60, 406.

has recently been resolved by Rosenheim and Plato¹ into active components, the asymmetry of the molecule being explained by supposing that the molecules of catechol lie round the arsenic atom in the same manner as ethylenediamine molecules lie round the metal atom in the case of metalampine compounds. It would thus appear that though chromium and the elements of the transitional group have yielded the largest number of active compounds as they readily form complex compounds, recent work shows that there is no bar to other elements belonging to other groups of the Periodic Classification from yielding active co-ordinated compounds. All that is necessary is the formation of hexa-co-ordinated compounds and fulfilment of the conditions already laid down.

ORGANIC RADICALS NOT NECESSARY FOR OPTICAL ACTIVITY.

It is quite true that most of the active co-ordinated compounds contain organic radicals, such as oxalato group, ethylenediamine or dipyridyl, etc., but the presence of organic radicals is not certainly indispensable for the formation of active inorganic compounds. In fact, Werner² was able to resolve hexol-dodecammine-tetracobaltic-bromide



possessing high molecular rotation into optical isomers which contained no carbon compounds at all and in which the complex $[\text{Co}(\text{NH}_3)_4(\text{OH})_2]$ plays the part of ethylenediamine occupying two co-ordination positions. It is to be noted that all that is necessary is the existence of groups each of which can occupy two co-ordination positions and it is immaterial whether such group is organic or inorganic. Because organic reagents like ethylenediamine are easily available in the laboratory, they are commonly used, and it is on that account commonly but mistakenly supposed that the presence of organic radicals is necessary in co-ordinated compounds for their resolution. The actual resolution of purely inorganic compounds devoid of carbon compounds has therefore once for all negated the hypothesis that optical isomerism is a property exclusively associated with organic compounds or radicals. The success of asymmetric synthesis of organic compounds and especially self-resolution of racemic compounds on mere recrystallisation at their transitional temperatures, shows the out-of-date character of the observations of Professor Japp³ who remarked 'only the living organism with its asymmetric tissues or the asymmetric products of the living organism, or the

¹ Rosenheim and Plato, *Ber.*, 1925, 58, 2000.

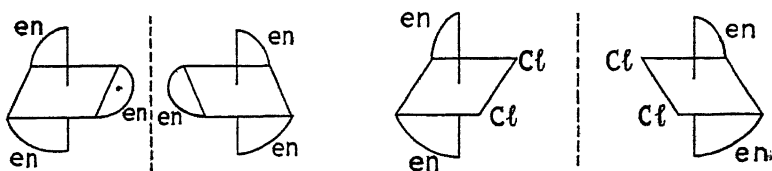
² Werner, *Compt. Rend.*, 1914, 154, 426.

³ Japp, Presidential Address to the Chemistry Section of the British Association, 1908.

living intelligence with its conception of asymmetry, can bring about the isolation of the single asymmetric compound'. The tendency of modern science is to explain all vital phenomena as results of physicochemical changes and therefore the resolution of a purely inorganic compound into optical isomers is of supreme interest as indicating the phenomenon of optical isomerism to be independent of vital function or even of organic compounds. We would therefore be not wrong in considering all co-ordinated complex compounds as inorganic compounds though they might contain organic radicals.

MOLECULAR ASYMMETRY AND ACTIVITY OF CO-ORDINATED COMPOUNDS.

Both Van't Hoff and Le Bel postulated in the case of carbon compounds that for optical isomerism to exist, the molecule of the compound must contain at least one carbon atom joined to four different radicals and as soon as two radicals become same optical isomerism vanishes. This is true in the case of simple carbon compounds, but one important lesson we learn from the successful resolution of co-ordinated compounds is that this condition is not in fact indispensable for optical isomerism as originally supposed by Van't Hoff and Le Bel. The resolution of bis- or tris-ethylenediamino or similar compounds for instance,



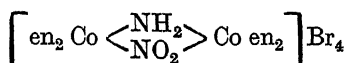
undoubtedly proves that Van't Hoff and Le Bel's condition is only a part of a wider truth. Their space representations appear to be highly symmetrical but nevertheless they show that asymmetry exists in their molecules as each compound and its mirror image are non-superposable. This criterion, viz. molecular asymmetry, and *not the existence of different radicals attached to the central element*, is therefore the indispensable condition for a compound to be able to exhibit optical isomerism. The same lesson is learnt from the constitution of the newly discovered co-ordinated compounds of beryllium, copper and zinc with benzoyl pyruvic acid and also of co-ordinated arsenic and boron compounds already referred to p. (9).

This deviation from Van't Hoff and Le Bel's conception has been recognised in the case of organic compounds as well. As early as 1893 Maquenne was able to resolve one of the isomeric inositols $C_6H_{12}O_6$ which does not contain any asymmetric

carbon atom of the orthodox type. Further instances of the resolution of organic compounds containing no asymmetric carbon atoms but containing an asymmetric molecule are those of 1-methyl-cyclo-hexylidene-4-acetic acid by Pope, Perkin, and Wallach,¹ of 4-oximino-cyclohexane-carboxylic acid by Mills and Bain² and the recent resolution of the Keto-dilactone of benzophenone 2 : 4 : 2 : 4-tetracarboxylic acid by Mills and Nodder.³ It is therefore firmly established from the resolution of both organic as well as co-ordinated inorganic compounds that an important part of the Van't Hoff-Le Bel theory requires substantial modification and all that is necessary for optical isomerism is that the molecule of the compound should be asymmetric and that the compound will be non-superposable with its mirror image, viz. its optical antipode.

TARTARIC ACID TYPE.

As is well known, compounds like tartaric acid containing two asymmetric carbon atoms yield besides the dextro-, lævo-, and racemic isomers, a meso-variety in addition. Search for an analogous compound of the tartaric acid type amongst inorganic co-ordinated compounds resulted in the discovery in 1913 of compounds containing two cobalt atoms each containing bis-ethylenediamine groups. Werner⁴ was able to show that tetraethylenediamine- μ -nitro- μ' -imino-dicobaltic bromide



could be resolved into dextro and lævo varieties and also yielded a meso isomer which was incapable of resolution. Another such compound resolved which possesses the distinction of possessing one of the largest molecular rotation of any optically active compound is tetraethylenediamine- μ -peroxo- μ -mon-imino-dicobaltic nitrate.⁵ These compounds belong to the polynuclear series in which the groups NH_2 , O_2 , NO_2 , and O_4 from bridging groups, and in the meso-compound a plane of symmetry passes through the bridging groups NH_2 and NO_2 in the first case and NH_2 and O_2 in the second case.

PASTEUR'S METHODS OF RESOLUTION.

Every organic chemist is familiar with Pasteur's three classical methods of resolution of racemic compounds into

¹ Pope, Perkin and Wallach, *Trans. Chem. Soc.*, 1909, 95, 1789.

² Mills and Bain, *Trans. Chem. Soc.*, 1910, 97, 1866.

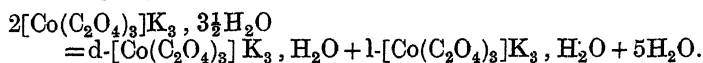
³ Mills and Nodder, *Trans. Chem. Soc.*, 1920, 117, 1407; 1921, 119, 2094.

⁴ Werner, *Helv. Chim. Acta.*, 1918, 1, 5.

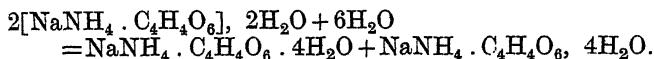
⁵ Werner, *Ber.*, 1914, 47, 1961.

optical isomers, viz. (1) self-resolution, (2) resolution by combination with an active compound, and (3) biological method.. All these three methods have been employed for the resolution of co-ordinated inorganic compounds with varying success. The third method, viz. resolution by living organism such as green mould, fungi and bacteria has been tried but found unsuccessful in the resolution of co-ordinated inorganic compounds.

So far as self-resolution on crystallisation is concerned, one case of resolution of a co-ordinated compound is on record, viz. that of potassium cobalti-oxalate $[\text{Co}(\text{C}_2\text{O}_4)_3] \text{K}_3$ by Jaeger and Thomas.¹ The transition temperature of resolution was found to be 13.2° close to which crystallisation of the racemate yielded crystals of the two active forms spontaneously. The racemate crystallises with $3\frac{1}{2}$ molecules of water and the active forms with one molecule, so that near the transition temperature resolution is effected with the liberation of $5\text{H}_2\text{O}$ according to the following equation:—



The organic analogy lies in the classical resolution by Pasteur of sodium ammonium racemate $\text{NaNH}_4\text{C}_4\text{H}_4\text{O}_6$ followed by resolution of many other compounds by crystallisation. The transition temperature in the case of sodium ammonium racemate is 27° and changes in amounts of water liberated or absorbed are effected according to the following equation:—



Self-resolution has a special theoretical significance as has already been pointed out. Co-ordinated active inorganic compounds have not been found in nature, but if any is found in the future this instance of self-resolution shall have the same theoretical significance as that of organic compounds which have been resolved in larger numbers.

The second method of Pasteur's, viz. resolution by combination with active compounds, which has so largely been employed in the resolution of organic compounds, has almost exclusively been employed in the resolution of inorganic compounds. The principal compounds which have been employed in the resolution of inorganic compounds are the following:—

Acids—tartaric acid, bromotartaric acid, camphoric acid, bromocamphoric acid, bromocamphor-sulphonic acid, and nitrocamphor. Several compounds which were not resolved by the other active acids have been resolved by the last named compound.

* 1 Jaeger and Thomas, *Proc. Kon. Akad. v. Wet.*, 1918, 21, 702.

Bases—alkaloids like quinine, brucine, strychnine, cinchonine, etc. α -Phenyl-ethylamine $C_6H_5.CH(NH_2).CH_3$ has been found to be a suitable base for resolution where alkaloids have failed to resolve.

Werner¹ has been able to show that the addition of crystals of an isomorphous form of one of the active varieties is able to cause resolution. With the addition of crystals of d-oxalato-diethylenediamine-cobaltic bromide $[Coen_2(C_2O_4)]Br$ he was able to resolve compounds like $[Coen_2(NO_3)_2]Br$, $[Cren_2(C_2O_4)]Br$, etc. This compound contains both acid and basic radicals so that it may be used in the resolution of both basic and acidic complexes and deserves trial on a much larger scale than hitherto attempted.

RACEMISATION AND MUTAROTATION.

Racemisation and mutarotation are common phenomena with optically active organic compounds and both these phenomena have been observed in the case of active inorganic compounds as well. Werner found that solutions of active trisdipyridyl ferrous chloride² $[Fe(Dipyr)_3]Cl_2$ and potassium chromi-oxalate³ $[Cr(C_2O_4)_3]K_3$ become racemic very readily.

Mills and Gotts⁴ have shown that the brucine salts of the active beryllium compounds of benzoyl pyruvic acids undergo mutarotation in chloroform solution giving the same dextro-value in each case. They have also shown that the active zinc and copper salts of benzoyl pyruvic acid behave in the same manner. Burgess and Lowry⁵ have shown that active beryllium benzoyl camphor exhibits marked mutarotation.

As regards theories to explain racemisation, the current theories of Werner and others applicable to organic compounds are clearly inadmissible to the case of these inorganic compounds as the constitution of the latter is so different from that of the former. The same is true of mutarotation, and comprehensive theories to explain mutarotation and racemisation of co-ordinated inorganic compounds are still awaiting further work on the subject.

LANDOLT-OUDEMANS' LAW.

So far as organic compounds are concerned it is well known that solvents exert very great influence on rotations; for instance, taking non-electrolytic solvents, ethyl-l-mandelate has a specific rotation of -90.6° in acetone solution whilst in

¹ Werner, *Ber.*, 1914, 47, 1955; 2171; 2179.

² Werner, *Ber.*, 1912, 45, 434.

³ Werner, *Ber.*, 1912, 45, 3065.

⁴ Mills and Gotts, *Trans. Chem. Soc.*, 1926, 3021.

⁵ Burgess and Lowry, *Trans. Chem. Soc.*, 1924, 125, 2081.

chloroform solution the rotation is double, though molecular weight remains the same. With electrolytic solvents like water, Landolt and Oudemans have shown that equivalent quantities of salts of active acids or alkaloids in dilute aqueous solution possess the same rotation independently of the metal, in the case of acids, and of the acid radical, in the case of alkaloids. On increased dilution the activity gradually approximates the rotation of the active constituent. In cases where both the constituents of a salt, acidic as well as basic, are active, its activity in dilute aqueous solutions approximates to the combined activity of the two ions.¹ Graham² studied the variation of the optical activity of several inorganic salts of d-camphor- β -sulphonic acid and found, contrary to Oudemans-Landolt Law, the following:—

(1) in the case of some salts, no appreciable change in rotatory power;

(2) in the case of some a diminution in rotatory power;

(3) in the case of other salts an increase in rotatory power.

So far as co-ordinated inorganic compounds are concerned no comprehensive work has yet been undertaken to ascertain as to what extent Landolt-Oudemans' Law is applicable to these classes of compounds. Work on this subject is certainly desirable.

PROPYLENE-DIAMINE COMPOUNDS.

The discovery of the great majority of the theoretically possible sixteen active isomers of the hexoses $C_6H_{12}O_6$ constitutes a triumph both for the manipulative skill of the organic chemist as well as for the tetrahedral space representation of the carbon atom. Werner has been able to achieve a similar triumph in the case of co-ordinated compounds whilst substituting propylene-diamine $CH_3 \cdot CH(NH_2) \cdot CH_2(NH_2)(=pn)$ for ethylene-diamine which on account of the existence of an asymmetric carbon atom in itself exists in dextro, lævo, and racemic varieties. Werner combined each variety with cis- and trans-modifications in the following manner and was actually able to prepare each of the isomers to which he also assigned proper constitutional formulæ. He prepared the following series of such compounds:

(a) Ethylenediamine-propylenediamine compounds.

By replacing one molecule of ethylene-diamine by one of propylene-diamine in cis- and trans-positions, theoretically eight active forms of the cis- (flavo) and two of the trans- (croceo) salts may be obtained. Werner³ was able to prepare all these

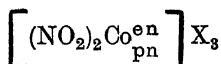
¹ Landolt, *Ber.*, 1873, 6, 1077.

Oudemans, *Ann.*, 1879, 197, 48.

² Graham, *Trans. Chem. Soc.*, 1912, 101, 746.

³ Werner, *Helv. Chim. Acta.*, 1918, 1, 5.

compounds of the type cobaltic dinitro-ethylene and propylene-diamine salts



(b) Tris-propylene-diamine compounds.

Twelve isomers could be theoretically obtained of the complex compound $[\text{Copn}_3]\text{Cl}_3$, propylene-diamine being taken in its three isomeric forms. Werner¹ was able to prepare all the twelve isomers. Agreement between prediction and experiment constitutes the surest proof of the correctness of a theory, and the remarkable coincidence of the experimental results in respect of the predicted number of the propylene-diamine compounds constitutes a strong proof of the correctness of the theory of the octahedral formula of co-ordinated inorganic compounds.

ROTATORY DISPERSION.

The magnitude of the rotation of optically active compounds is usually determined with reference to monochromatic sodium light. The rotation of many organic compounds has, however, also been determined with reference to light of different wavelengths, and interesting relations have been obtained. Biot found that the rotation of active compounds when measured in the presence of light of different wavelengths bears an inverse proportion to the square of the wavelength or

$$[\alpha] = \frac{k}{\lambda^2}.$$

This is normal dispersion, but in many cases anomalous dispersion is observed in which the rotation increases with increase of wavelength and decreases with its decrease.

So far as dispersion of co-ordinated inorganic compounds is concerned, some work has been done by Jaeger² with complex salts of cobalt, chromium, rhodium, and iridium. Some of the results obtained are stated below:—

(1) The nature of the dispersion curve of tris-ethylene-diamine cobaltic salts is chiefly dependent on the complex and almost independent of the chloride, bromide, iodide, nitrate, ions.

(2) The colour of the solution has great influence on the nature of the dispersion curve and hence there is a great similarity in the dispersion curves of the corresponding cobalt and chromium complex salts which give similarly coloured solutions and of those of rhodium and iridium salts which impart a similar colour to the solution.

(3) The magnitude of the rotation of iridium and rhodium-

¹ Werner, *Helv. Chim. Acta.*, 1917, 1, 5.

² Jaeger, *Proc. Kon. Akad. v. Wet.*, 1915, 17, 1231.

complex salts was found to conform to Biot's rule, viz. it decreases with increasing wavelength of the source of light. Anomalous dispersion has however been met with in the case of potassium rhodi-oxalate, potassium cobalti-oxalate, and other salts. Drude's equation does not appear to have been tested in the case of inorganic complex compounds.

PASTEUR'S SECOND LAW.

Pasteur postulated that asymmetric molecules would produce enantiomorphous crystals with hemihedral facets. In the case of organic compounds themselves numerous exceptions to Pasteur's second law have been observed but their number is gradually decreasing owing to the discovery of more advanced methods of detection of enantiomorphous forms of crystals. With the discovery of the optically active inorganic compounds the question arose if Pasteur's second law was applicable to these compounds or not. The experimental work was undertaken by Jaeger¹ who examined the active hexa-co-ordinated compounds of the type $[Men_3]X_3$ as well as $[M(C_2O_4)_3]K_3$ containing basic and acid radicals respectively. These compounds possess high specific and molecular rotations as well, but his results are not very favourable to Pasteur's law. Hemihedrism was no doubt detected in many cases but it was found to be very feebly developed in most crystals. Thomas could detect no hemihedrism in the active forms of ammonium oxalato-cis-dinitro-cis-diammine-cobaltiate $[Co(NO_2)_2(NH_3)_2C_2O_4]NH_4$. More work on the subject would be necessary to state definitely as to what extent Pasteur's second law is really applicable to co-ordinated active compounds.

WALDEN INVERSION.

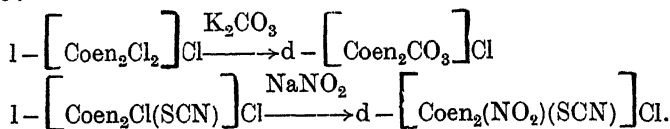
Every student of organic chemistry is familiar with the phenomenon of Walden inversion, viz. optical inversion effected during replacement of groups in an active compound. The literature on the organic side is very voluminous and more than half a dozen theories by Fischer, Werner, Gadamar, Freudenburg, Clough, Billman, and others which seek to explain the phenomenon are in vogue. The subject has not been studied with the same thoroughness either on the theoretical or experimental side with reference to co-ordinated inorganic compounds. Nevertheless some interesting results involving Walden inversion have been recorded by Werner² himself. He studied the action of potassium carbonate, sodium nitrite, potassium thiocyanate on active co-ordinated compounds and measured the rotation of the substitution compounds when it was found that in some cases inversion had taken place whilst in some

¹ Jaeger, *Rec. des Trav. Chim. des Pays-Bas*, 1919, 38, 171.

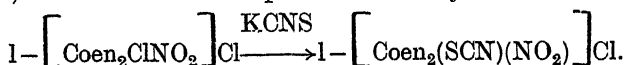
² Werner, *Ber.*, 1912, 45, 1229.

others substitution was effected without change in the sign of rotation. The following results are illustrative:—

(1) Inversion with potassium carbonate and sodium nitrite:—



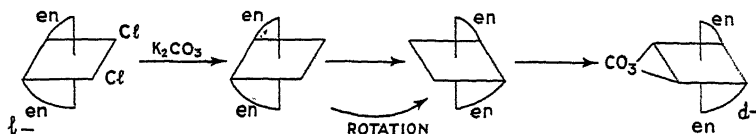
(2) No inversion with potassium thiocyanate:—



There is very little scope for generalisation from this meagre amount of experimental work done by Werner alone. In the case of organic compounds a difference is observed in the action of even different alkalis and oxides so far as Walden inversion is concerned, the hydroxides of rubidium, potassium, ammonium, copper, cadmium, barium, lead, and sodium causing inversion whilst the oxides of silver, thallium, and mercury causing no change in the sign of rotation. Solvents have been found by Senter and Drew to have remarkable influence on Walden inversion whilst the action of all manners of reagents has been studied in great detail by different workers. More recently Freudenburg, Hudson, Clough, and others have shown that mere change in the sign of rotation does not signify change in the constitution of the molecule during Walden inversion. They have shown that l-lactic, l-glyceric, d-malic, and d-tartaric acids are co-related in configuration as they behave similarly with reference to temperature, solvent, action of neutral salts, etc. Similarly d-alanine, d-valine, l-serine, and l-leucine have been found to belong to the opposite series of similarly constituted compounds. A case of Walden inversion is therefore not always a case of real inversion but may be a normal change whilst the reverse might be the case in an apparently normal transposition.

So far as co-ordinated inorganic compounds are concerned, Werner himself has postulated that the compounds $1 - [\text{Coen}_2\text{Cl}_2]\text{Cl}$ and $d - [\text{Coen}_2\text{CO}_3]\text{Cl}$ possess similar configurations and therefore potassium carbonate does not produce real inversion. Similarly $1 - [\text{Coen}_2\text{Cl}(\text{SCN})]\text{Cl}$ and $d - [\text{Coen}_2(\text{NO}_2)(\text{SCN})]\text{Cl}$, according to Werner, have similar configurations and the Walden inversion observed with sodium nitrite is really a normal reaction. The main reason for Werner's supposition lies in the fact that the two pairs of compounds with opposite rotations mentioned above are easily obtained at the time of the resolution of the corresponding racemic bodies with d-bromo-camphor sulphonic acid, when the first fractions yielded the two pairs though they possessed opposite rotations.

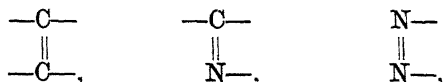
Whether Werner's conclusions are correct or not will be ascertained when a much larger amount of experimental work on the subject will be forthcoming in the future. But in case these and other instances are proved to be real cases of optical inversion, the theories so far advanced to explain Walden inversion of organic compounds will not clearly explain the inversion of inorganic compounds and new theories have got to be postulated to explain Walden inversion of co-ordinated inorganic compounds which possess constitutions so very different from those of organic compounds. The author ventures to point out that the possible stages of the potassium carbonate reaction mentioned above involving, for the sake of argument, Walden inversion would be represented as follows :—



This will necessitate a rotation of the octahedron during the replacement of radicals under the experimental conditions when optical inversion results. In the case of a normal reaction no rotation of the octahedron takes place. This explanation is similar to that put forward by the author in the case of geometrical inversion of organic compounds, the main differences lying in (1) the presence of double bonds in the organic geometrical isomers and absence of same in inorganic co-ordinated compounds, (2) the tetrahedral structure of the carbon atom and octahedral structure of co-ordinated compounds. The author intends to develop this theory elsewhere in greater details.

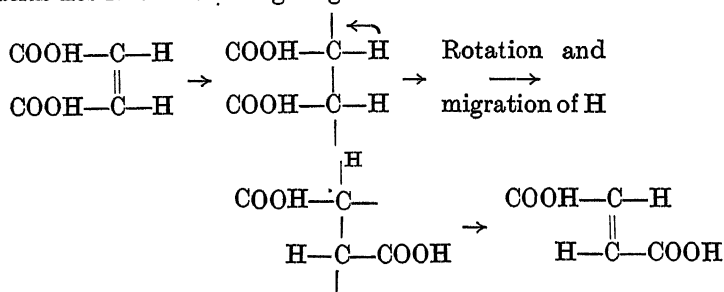
WERNER INVERSION.

Geometrical isomerism in the case of organic compounds is associated with the presence of a doubly-bound system of two carbon, one carbon and one trivalent nitrogen or two trivalent nitrogen atoms,



but in the case of co-ordinated inorganic compounds geometrical isomerism has nothing to do with double bonds and is associated with difference in structure of an entirely different nature. It is outside the scope of this paper to deal with geometrical isomerism which, on account of its intrinsic importance and absence of optical activity, merits separate treatment. There is one aspect, however, of geometrical isomerism which is referred to here, viz. a form of geometrical inversion which has similarity to Walden inversion.

Geometrical inversion in the case of organic compounds, such as maleic and fumaric acids, oximes, diazo-compounds, etc. has been explained by different workers like Wislicenus, Werner, Anschütz, Stewart, Cohen, and others in different ways. The formation of intermediate compounds as postulated by Wislicenus has definitely been shown by Anschütz and others to be untenable whilst the explanation given by Cohen¹ will be found to be faulty, as pointed out by the author of this paper, so far as the last stage is concerned, which can easily be ascertained by any one on trying the usual illustrative models. The author² has shown that the best method of explaining the mechanism of the inversion of geometrical isomers like maleic and fumaric acids lies in the following stages:—



which is effected either way according to the following experimental conditions:—

Agents—Conversion of labile to stable variety.	Conversion of stable to labile variety.
Low frequency radiations.	High frequency radiations.
1. Heat. 2. Light.	1. Higher temperature.
Catalytic agents.	2. Ultra-violet rays.
Exothermic reactions.	

Geometrical inversion of co-ordinated inorganic compounds, it must be noted at the very outset, is in many respects of a very different nature, inasmuch as geometrical isomerism of these compounds itself is so differently constituted and has nothing to do with double bonds. The cis-trans isomerism of co-ordinated inorganic compounds containing, for instance, the complex $[\text{MA}_4\text{B}_2]$ is due to the relative positions of the groups A_4 and B_2 in space in the octahedral molecule. Geometrical isomerism and inversion of co-ordinated inorganic compounds thus possess very notable features not met with in the case of organic compounds, but the subject nevertheless has not attracted the attention of the organic chemist to the extent the importance of the subject in relation to organic compounds

¹ Cohen, *Theoretical Organic Chemistry*, Vol. II, 1928, p. 281.

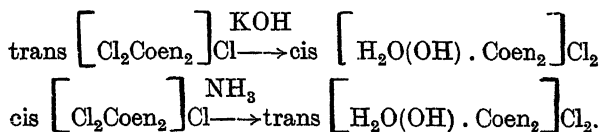
² Neogi, *Chem. News*, 1930, Aug. 30th.

would warrant. Geometrical inversion of inorganic compounds is met with in two forms :—

(1) ordinary cis-trans transformations, e.g.

transformation¹ of trans-dichloro-diethylenediamino-cobaltic chloride praseo-salt $[\text{Coen}_2\text{Cl}_2]\text{Cl}$ to the corresponding cis- or violo-salt by evaporating a solution of the salt at 100° till the weight is constant, the transformation being almost complete ;

(2) geometrical inversion occurring during replacement of radicals similarly to Walden inversion, e.g.



Many other examples are known and in several cases mixtures of cis- and trans-compounds are obtained. In most cases of this nature there is a transference of radicals from inside the co-ordination to the outside and vice versa.

This latter form of inversion is so common in the case of inorganic co-ordinated compounds that the author would like to give it a separate name and call it Werner inversion as it is so akin to Walden inversion in the case of optically active compounds. It is true that in the case of organic compounds, geometrical inversion takes place during addition of bromine, halogen acids, etc. to unsaturated labile geometrical isomers, but geometrical inversion during substitution of radicals in organic compounds is not a very common phenomenon. It is to be noted, as has been pointed out above, that ordinary geometrical inversion, viz. conversion of one geometrical isomer to the other is also known amongst inorganic compounds, but Werner inversion, which connotes geometrical inversion during replacement of radicals in geometrical isomers, is also very common amongst them. Such cases amongst organic compounds, the author would venture to suggest, should also be called by the new name suggested here.

As regards theories, it is apparent that the theories so far advanced to explain the mechanism of geometrical inversion of organic compounds will not apply here. The author therefore intends to draw the attention of chemists to this important question so that a satisfactory theory may be evolved to explain not only Werner inversion but also geometrical inversion of co-ordinated inorganic compounds in general. In the meantime the author will like to emphasise that :—

(a) In ordinary geometrical inversion of compounds like bis-ethylenediamine cobalt compounds a transference of one bi-

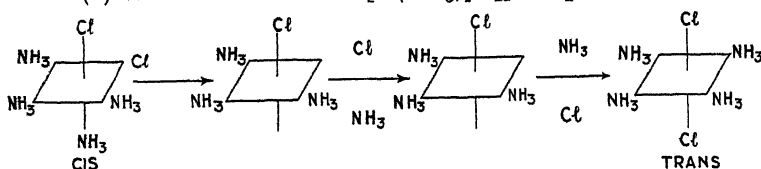
¹ Werner, *Ber.*, 1901, 34, 1705.

co-ordinated group like ethylenediamine takes place and the acid radical takes the place of one of the vacant positions.

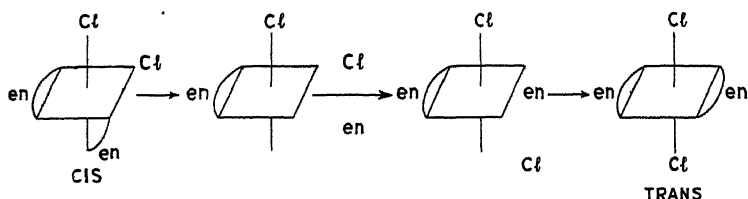
(b) In Werner inversion a transference of radicals takes place from inside the co-ordination to the outside and vice versa, and it is during this transference inversion occurs by the rearrangement of groups including groups like ethylenediamine occupying two co-ordination positions.

The author would suggest the following stages in the mechanism of geometrical and Werner inversions:—

(1) Cis-trans inversion of $[M(NH_3)_4Cl_2]$ compounds

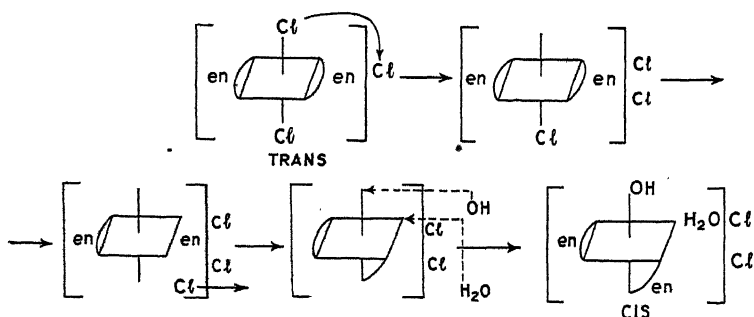


(2) Cis-trans inversion of $[M en_2Cl_2]$ compounds



In the first case NH_3 and Cl and in the second, en and Cl get loosened from their bonds and then under the conditions of the experiments seek new vacant positions.

(3) Werner inversion



In Werner inversion the state of affairs is more complex and radicals go out of the co-ordination and also come inside. Radicals, including en groups, get loosened from their bonds and occupy other vacant positions under the conditions of the experiments. It is the intention of the author to deal with this interesting subject elsewhere in greater details.

REMARKABLY HIGH ROTATION OF CERTAIN CO-ORDINATED ACTIVE INORGANIC COMPOUNDS.

It is not generally known that active co-ordinated inorganic compounds often possess very high rotations and in fact the race between organic and co-ordinated inorganic compounds for possession of the trophy for the highest specific and molecular rotations has been a very close one. So far as organic compounds are concerned, optical rotation largely increases with the introduction of one or more double bonds and specially of conjugated double bonds. Hilditch¹ has been able to obtain very high rotations by the introduction of the group $O=C-C=CHR$. Camphor has a molecular rotation of $+67.2^\circ$ only, whilst benzylidene camphor has a molecular rotation of $+1020.3^\circ$, and whilst thujone has a molecular rotation of $+113.2^\circ$, the molecular rotation of piperonylidene thujone is $+2172.6^\circ$. Forster and co-workers² have, by increasing the number of conjugated bonds, prepared organic compounds such as p-phenylene bis-imino camphor of much higher rotation, whilst B. K. and M. Singh,³ by substituting naphthalene in the place of phenylene radical in Forster's compound, succeeded in preparing 1 : 4 naphthalene bis-imino camphor, and found that its molecular rotation in chloroform solution was 8175° and in pyridine solution as high as $13,416$.

So far as co-ordinated inorganic compounds are concerned, high rotations have not been obtained by the introduction of any double or conjugated double bonds but by entirely different methods. In their case the following principles hold good :—

(1) So far as the ionisable group outside the co-ordination is concerned it exerts some, though not large, influence on the magnitude of the molecular rotation as the following results will show :—

d-Dichloro-bis ethylenediamino-chromic

chloride,	[M] = $+415.1^\circ$
bromide,	„ = $+400.5^\circ$
nitrate,	„ = $+372^\circ$

(2) The magnitude of the rotation is largely dependent on the central atom as the rotations of the corresponding cobalt and chromium compounds will show :—

d-Dichloro-bis ethylenediamine cobalt chloride, [M] = $+558^\circ$

bromide,	„ = $+554^\circ$
nitrate,	„ = $+511^\circ$

¹ Hilditch, *Trans. Chem. Soc.*, 1909, 95, 1578; 1911, 99, 224.

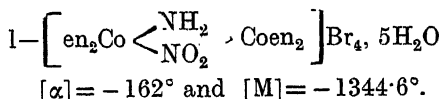
² Forster and Thornley, *ibid.*, 1909, 95, 942.

Forster and Saville, *ibid.*, 1921, 119, 791.

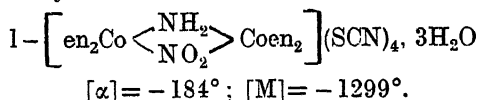
³ B. K. and M. Singh, *ibid.*, 1920, 117, 1599.

The molecular rotations of the corresponding chromium salts have been given above, and on comparison it will be observed that cobalt compounds possess a higher rotation than the corresponding chromium compounds.

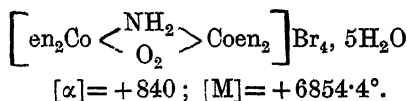
(3) The magnitude of the rotation largely increases in the polynuclear compounds¹ containing two Coen_2 groups bridged by groups like NH_2 and NO_2 , e.g. 1-tetra-ethylene diamino- μ -amino-nitro-dicobaltic bromide



The thiocyanate



(4) In the corresponding polynuclear peroxo-compounds² we meet with still higher rotations in which one of the bridging groups is O_2 , e.g. d-tetra-ethylenediamino- μ -amino-peroxo-dicobaltic bromide



The d-thiocyanate

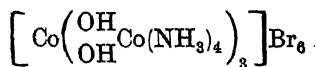
$$[\alpha] = +848; [\text{M}] = +6919.6^\circ.$$

The d-nitrate containing $2\text{H}_2\text{O}$

$$[\alpha] = +920; [\text{M}] = +6348^\circ.$$

(5) Still higher rotations are obtained in tetracobaltic compounds,³ which contain no organic radicals, and in which abnormal rotatory dispersion is observed, and the highest specific rotations observed in the following compound are the following:—

d-dodecammino-hexol-tetracobaltic bromide



d-compound, $[\alpha] = +4446^\circ$

and l-compound, $[\alpha] = -4500^\circ$;

their molecular rotations would therefore be amazingly high viz. about 45,000°

¹ Werner, *Ber.*, 1913, 46, 3674.

² Werner, *Ber.*, 1914, 47, 1961.

³ Werner, *Ber.*, 1914, 47, 3087.

It would therefore have to be conceded that the trophy for the highest specific and molecular rotations has been won by inorganic compounds.

The foregoing short account clearly demonstrates that the study of optical isomerism of co-ordinated inorganic compounds has many lessons for the organic chemist. The current theories of mutarotation, racemisation, Walden inversion, geometrical and Werner inversions, based on a study of organic compounds are clearly inapplicable to these compounds and the chemistry of rotatory dispersion, relation of constitution to optical activity, molecular asymmetry, hemihedrism and allied subjects has got to be re-written in view of the new light obtained from a study of the stereo-isomerism of inorganic compounds. This subject is only of twenty years' growth, the first inorganic compound having been resolved, as has already been noted, in 1911. A large amount of spade work has been accomplished but much more remains to be done. The joint collaboration of the inorganic and the organic chemist is absolutely necessary to complete the picture, the faint outlines of which have been drawn so far. A supremely seriously-minded chemist has calculated the money value of the constituent elements comprising the compounds of which human body is built up in the following picturesque words : 'The fat contained in an adult human body is sufficient to make seven bars of soap ; the iron is enough to make a medium size nail ; the sugar, enough to fill a sugar-dredger ; the lime, enough to whitewash a chicken-coop ; the phosphorus, enough to make fifty-five ordinary boxes of matches ; the magnesium, sufficient for a dose of magnesia ; and the sulphur, enough to rid a dog of fleas. In addition there is about thirteen gallons of water ! Were these substances in the pure state they would, all told, be worth not more than seven shillings and six pence.' But it must frankly be admitted that seven shillings and six pence worth of soap, matches, iron nail, magnesia, lime, and sulphur or even million times the amount will not make any human body, even the dwarf or the pigmy.

Plants are made of much the same elements as the human body, and the average organic chemist who is unable to be so worldly-wise as the above-mentioned gentleman is busy in examining the numerous complex compounds formed by the elements mentioned above and found both in the animal and vegetable kingdoms, as well as in finding out the methods by means of which these compounds so operate as to form living cells which form life. His discoveries in optical isomerism which emanated from his examination of these natural products have been introduced into inorganic compounds, as has been shown above, with far-reaching results. The inorganic chemist who has also discovered numerous classes of co-ordinated inorganic compounds with as complex constitutions as organic ones is however in great need of the assistance of the

organic chemist in assimilating the latter's ideas of optical and geometrical isomerism and inversion, and I would once again venture to invite the co-operation of the votaries of both the branches of chemistry in the task of completing the work which was started so ably by the immortal Alfred Werner and his associates almost contemporaneously, by curious coincidence, with the foundation of the Indian Science Congress itself.

Section of Chemistry.

Abstracts.

1. Natural gas from Assam and Burma.

G. P. KANE and K. R. KRISHNASWAMI, Bangalore.

A number of samples of natural gas from the Assam and Burma oil-fields has been examined with special reference to their helium content. The methods of analysis and the results are given.

2. An examination of a very insoluble phosphate extracted from Monazite obtained from Orissa.

C. B. ROY and S. B. ROY, Patna.

While analysing Monazite in the black sands of Orissa, a very refractory phosphate was left behind after repeated bisulphate fusions, which was believed to be either wholly salt of zirconium or some new element or mixture of both. A sample of crude chloride prepared from this phosphate was found by Dr. Hevesy of Copenhagen to contain about 2% of Hafnium discovered in 1923. A short report of this work was published in *Welfare*, India, May, 1925.

The chloride after further purification was again examined. Equivalent weight determination from chloride and sulphate was attempted. Atomic weight deduced, gave values ranging from 99 to 107.5. A report on the spectroscopic examination of the purified salt by Prof. Kamta Prasad, Patna, is appended. Prof. Hopkins of Illinois University, after examination in his laboratory of a sample of salt prepared by the authors, confirmed their previous conclusions of the salts originating from zirconium. Some characteristics, however, of the salts remain unexplained on the assumption that it is a pure zirconium salt.

3. The mechanism of hydrolysis of magnesium boride.

R. C. RAY and P. C. SINHA, Patna.

Magnesium boride was prepared by heating rapidly to red-heat an intimate mixture of freshly prepared and finely powdered boron trioxide and magnesium. The mixture of magnesium boride and oxide, thus obtained was powdered and added, in small quantities at a time, to a mixture of absolute alcohol and hydrochloric acid of different strengths kept in a bottle provided with a stirrer and immersed in crushed ice. Hydrogen was rapidly evolved and a white powder, which was free from magnesium oxide and free boric acid, separated. The compound is inactive towards both cold and hot water and has the composition $Mg_3B_2(OH)_6$. This appears to be the main product of hydrolysis of magnesium boride. There is, however, some evidence of the formation of an intermediate compound, but it has not yet been possible to isolate it.

4. Fluoberyllates and their analogy with sulphates.

Part V.—Double fluoberyllates of some of the bivalent metals with thalious fluoberyllate.

NIRMALENDUNATH RAY, Rajshahi.

Preparation of thalious fluoberyllate has already been described (Ray, *Zeit. anorg. chem.*, 201 [1931], 297). Equimolecular quantities of

this salt and a fluoberyllate of a bivalent metal such as Ni, Co, Zn, etc., were dissolved in the minimum quantity of water and allowed to crystallise. Crystals of the general formula $Tl_2 BeF_4 M^1 BeF_4 \cdot 6H_2O$ were obtained. These were isomorphous with the corresponding double sulphates described in a previous publication (Rây, *Zeit. anorg. chem.*, 206 [1932], 200).

5. Fluoberyllates and their analogy with sulphates. Part VI.
—The Hydrazinofluoberyllates.

NIRMALENDUNATH RÂY, Rajshahi.

The Hydrazinofluoberyllates analogous to the hydrazinosulphates of Franzen and Mayer have been prepared and their properties studied.

6. Dithiosulphato di-ethylenediamine cobaltates.

PRIYADARANJAN RÂY and S. N. MAULIK, Calcutta.

The preparation of a new series of complex cobaltates—sodium, potassium and thallium salts of dithiosulphato-di-ethylenediamine cobaltic acid—has been described and their properties studied in the present paper. With the two thiosulphato groups, each occupying one co-ordination position, these salts, as is well-known, should exist in cis-trans isomeric forms. This has been proved by preparing both the stereo-isomeric forms of the sodium salt, which differ widely in their colour, solubility, and other physical properties.

Attempts are being made to resolve the cis-modification of the salt into its optical antipodes.

7. Simple and complex iodates of tetravalent lead.

PRIYADARANJAN RÂY and HARIBOLA SAHA, Calcutta.

In continuation of our previous work on iodates of tetravalent tin and titanium, we have now been able to prepare tetra-iodate of lead, di-hydroxo-tetra-iodato plumbic acid, hydrated hexa-iodato plumbic acid and its alkali salts. The properties of the compounds have also been investigated.

8. Substituted complex cyano-cobaltates.

PRIYADARANJAN RÂY and T. GUPTA CHOWDHURY,
Calcutta.

Starting from di-sulphito-tetracyano-sodium cobaltate described by Rây and Chackrabarty, silver, lead, and alkali salts of a new type of complex di-aquo-tetracyano-cobaltates have been prepared and their properties studied. The highly soluble alkali salts are characterised by the unusual property of being changed into an insoluble modification on drying at the ordinary temperature.

9. The effect of tannin on the physical properties of clays.

P. Y. NARAYANA, H. E. WATSON, and M. A. GOVINDA RAO,
Bangalore.

Experiments have been conducted to ascertain if the commercial sodium tannate now used to reduce the viscosity of mud used for well-boring can be replaced by tannin materials of indigenous origin. It has been found that an extract of *Cassia auriculata* either alone or with the addition of sodium hydroxide behaves in a similar manner to sodium tannate and is in some respects more satisfactory.

10. Action of nitric acid on tin.

G. S. KASBEKAR, Bombay.

The reaction between nitric acid and tin under different conditions of concentration and temperature has been systematically studied by the estimation of all the following products formed during the reaction, viz.:—

Nitrate, Nitrite, Stannous and Stannic salt, Hydrazine, Hydroxylamine and Ammonia.

Estimation of the gases formed during the reaction is proceeding. It is found that in addition to the marked changes in the reaction products due to alterations in concentration, temperature, etc., certain catalysts greatly influence the velocity of reaction as also the nature of the products formed. Some catalysts have been observed to completely inhibit the reaction between nitric acid and tin.

11. Heat of formation of potassium tri-iodide.

S. S. JOSHI and SUBRAMANIAM IYER, Benares.

Based on experiments on the influence of temperature on the distribution coefficient of iodine between toluene and water, the latter containing varying proportions of potassium iodide, it has been deduced that the heat of KI_3 formation is very small in the temperature range 8° – $40^{\circ}C$.

12. Formation of Bromine-chloride.

S. ANWAR-ULLAH. *Cuthack*

The preparation of the bromine chloride was first claimed by Balard in 1826 and was confirmed by Löwig in 1829. Since then several observers have failed to find any evidence in favour of its existence. Recently photometric work and also the phenomena encountered in certain organic reactions, have definitely shown that bromine-chloride exists in equilibrium with bromine and chlorine. The author has brought about further proof of the formation of the bromine-chloride by the establishment of the equilibrium constant for the halogens and their compound and through the study of bromine-chloride hydrate.

13. Conductivity of bromine-chloride.

S. ANWAR-ULLAH. *Cuthack*

Experiments have been made to test whether the solutions of bromine-chloride mixtures also act in the same way as that of iodine-chloride and iodine-bromide in nitrobenzene, where the iodine separates at the cathode, for by analogy bromine-chloride might reasonably be expected to be ionised to some extent. It has been observed that solutions of bromine-chlorine mixtures do conduct. The addition of chlorine to bromine dissolved in pure dry nitrobenzene lowered the resistance of the latter solution to about one-third of its previous value. When solutions of the halogens were kept in a dish and two platinum electrodes were connected through a milli-ammeter to the mains the instrument moved over several divisions and a gas was evolved from the anode. No gas was detected at the cathode.

It seems difficult to interpret these observations except by the assumption that bromine-chloride is formed in solution and dissociates to some extent into positive bromine ions and negative chlorine ions.

14. Restoration of bronze images.

S. PARAMASIVAN, Madras.

The mechanism of corrosion and restoration of bronze images is extremely complex. Chemical methods of restoration have serious defects, especially in cases of heavily corroded bronzes. In restoring very heavy bronzes like the ones in the Government Museum, Madras, one finds it extremely difficult either to handle the bronze with ease or to regulate the chemical reaction during the progress of restoration. In these respects, the electrolytic or the Fink method has many advantages, and is the only effective method for eliminating 'Bronze Disease'. The Fink method, which has been in regular use in some of the prominent American Museums for restoring very small bronzes, has now been extended here for restoring heavy and large sized bronzes at the Government Museum, Madras. In this connection, the experimental technique has been developed here.

15. Attempts to synthesise p-diphenylene. Part II.

V. C. PAREKH and P. C. GUHA, Bangalore.

Some further work has been done in continuation of paper No. 134 (*Indian Science Congress Abstracts, Section of Chemistry, 1932*) by way of gathering facts for the elucidation of the structure of p-diphenylene-dimonsulphide. The paper embodies results obtained in our attempts to synthesise the above compound from pp-di-amino-di-phenyl-sulphide as also by the action of p-di-brom-benzene on the di-sodium derivative of p-di-mercaptan of benzene. The effect of other groups like $(CH_2)_n$, CO, and $(NH)_n$ in bridge formation between the two pairs of para carbon atoms of two benzene molecules is under investigation.

16. Action of ammonia and urea on carbo- and oxalyl-diurethane.

P. C. GUHA, Bangalore.

In continuation of the work described in paper No. 143 (*Indian Science Congress Abstracts, Section of Chemistry, 1929*) it has been found that urea reacting with oxalyl-diurethane gives, besides carbo-oxalyl-diurea and oxalyl-diurea, four more compounds, viz. (a) allophanic ester, (b) carbethoxyoxamide $NH_2 \cdot CO \cdot CO \cdot NH \cdot COOEt$, m.p. 157° , (c) dicarbethoxy-oxalyl-diurea m.p. 230° , and (d) a compound m.p. above 330° of the composition $C_5H_{10}O_5N_6$. In the course of the preparation of oxalyl-diurea from the urethane by the action of ammonia a compound m.p. 235° of

the structure $\begin{array}{c} CO-NH-CO \\ | \\ CO-NH-CO \end{array} > NH$ has been isolated. Carbodiurethane gives

the monoamide (m.p. 190°) with ammonia; and two compounds, viz.,

allophanic ester and $CO < \begin{array}{c} NH-CO-NH-CO-NH_2 \\ NH-CO-NH_2 \end{array}$ (m.p. 240°) with urea.

17. On a new method of synthesis of norpinic acid.

P. C. GUHA, Bangalore.

In the paper are described experiments conducted in the process of effecting condensation of brom- and chlor-acetol with methylene dimalononic ester on the one hand and isopropylidene dimalononic ester with methylene iodide on the other; and the conversion of the resulting 1:3-methylene: isopropylidene-2:4-dimalonic ester into the corresponding

tetracarboxylic acid. The latter on being freed from two molecules of carbon dioxide is expected to give norpinic acid (cf. Kerr, *J. Am. Chem. Soc.*, 1928, 51, 614; Clemo and Welch, *Trans.*, 1928, 2621; Ganguli, *J. Indian Inst. Sci.*, 1922, 23; Kotz, *J. Pr. Chem.*, 1907, 75, 494). Considerable improvement has been effected in the methods of preparation of chloracetol, bromacetol, and isopropylidene-malonic ester.

18. On the synthesis of uric acid from nine-membered polypeptides.

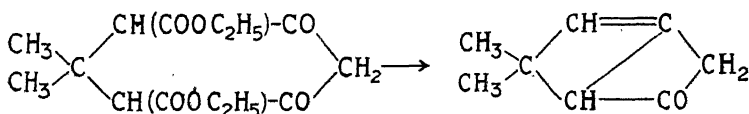
P. C. GUHA, Bangalore.

Though carbo-oxalyl-diurea and carbo-ethylene-diurea and what appears to be desoxy-uric acid (formed from the latter) have been synthesised and reported in the abstracts of the previous years; the actual synthesis of uric acid has not so far been possible to achieve due to the difficulties involved in the synthesis of carbo-glycolyl-diurea. The product reported in the *Indian Science Congress Abstract, Section of Chemistry*, No. 50 of 1930 to be carbo-glycolyl-diurea has now been found to be not a pure substance. The present paper embodies the results of a large number of experiments done so far with the object of preparing carbo-glycolyl-diurea and allied substances from which uric acid can be easily obtained. The action of urea and biuret has been studied upon carbethoxy-glycine ester, carbethoxy-glycineamide, glycolyl-diurethane, hydantoin ester and hydantoinamide under various conditions of experiments and quite a large number of compounds have thus been isolated.

19. Constitution of Isophorone.

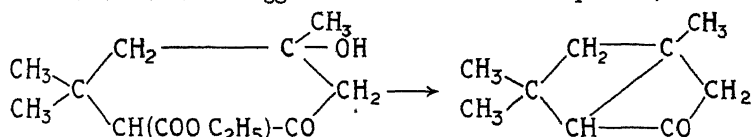
P. S. MAYURANATHAN, Bangalore.

A dicyclohexenone (*Indian Science Congress Abstract*, 1932, *Section of Chemistry*, p. 33) was discovered during the course of the following reaction:



Possibly, enolisation had taken place and dehydration subsequently resulted due to the presence of an active hydrogen para to the hydroxyl. The constitution was proved by preparing derivatives and also by bromination, hydrolysis, oxidation and reduction.

The above reaction suggests a new constitution for isophorone, viz.—



quite distinct from the already accepted tautomers proposed at different times by different authors.

The following evidences have so far been collected:—

- Isophorone is polymerised and a dimer is obtained.
- Isophorone is reduced by Clemmensen method and a hydrocarbon $\text{C}_{13}\text{H}_{32}$ is obtained. The constitution is being studied.
- The principle of the formation of isophorone is discovered in the necessity for the presence of the active hydrogen para to the hydroxyl. The moment it is substituted, there is

inhibition of dehydration and consequent hydrolysis. With methyl-aceto-acetic and propionyl-propionic esters the main products are the *ol*-esters, but with aceto-acetic ester only isophorone and the dehydro-ester are discovered.

20. On dicyclohexenones.

P. S. MAYURANATHAN, Bangalore.

Isobutylidene- and cyclopentylidene-malonic esters have been respectively condensed with aceto-acetic ester and the corresponding dicyclohexenones isolated. The constitution of the dicyclohexenones is proved on similar lines with the dimethyl analogue. A comparative study of their stability is being carried out. Work is extended to the higher homologues in the aliphatic and hydro-aromatic series.

21. On resorcin-esters.

P. S. MAYURANATHAN, Bangalore.

The following new resorcin esters have been synthesised :—

1. Ethyl cyclohexane-1-phenyl-3 : 5-diketo-4-methyl-2 : 6-dicarboxylate.
2. Ethyl cyclohexane-1 : 1 : 2-trimethyl-3 : 5-diketo-6-carboxylate.
3. Ethyl cyclohexane-1 : 1 : 4-trimethyl-3 : 5-diketo-2 : 6-dicarboxylate.
4. Ethyl cyclohexane-1 : 1 : 4-trimethyl-3 : 5-diketo-6-carboxylate.

During the formation and hydrolysis of some esters, interesting results are obtained which are being investigated. A generalisation for the condition controlling the internal dehydration in resorcin-esters is discussed.

22. Substitution in resorcinol derivatives : chlorination of nitro-derivatives of β -Resorcyaldehyde.

M. SESA IYENGAR and K. SANTANAM, Bangalore.

It has been pointed out that during the bromination of certain nitro-derivatives of β -Resorcyaldehyde an intra-molecular rearrangement takes place. (*J. Chem. Soc.*, 1932, 524.) The action of chlorine on the compounds referred to, is now being studied with a view to find whether such a rearrangement would take place during chlorination also. As a result of study, we have prepared 3-nitro-5-chloro-2-hydroxy-4-methoxy-benzaldehyde (m.p. 115-116°) and 5-nitro-3-chloro-aldehyde (m.p. 130-131°). Further chlorination of either the 3-nitro- or the 5-nitro-monochloro-derivative did not yield any definite compound. The bromination of the 5-nitro-3-chloro-2-hydroxy-4-methoxy-benzaldehyde yielded, however, a golden yellow substance (m.p. 120°) indicating an ortho-phenolic structure. Further work is in progress.

23. Resolution of co-ordinated inorganic compounds. Part I. d- and l-tri-ethylene-diamino-zinc chloride, bromide, iodide and sulphate.

P. NEOGI and GOPAL KRISHNA MUKHERJI, Calcutta.

Attempts have been made to resolve tri-ethylene-diamino-zinc salts and for this purpose the reagents chosen have been d-tartaric acid, d-camphor-sulphonic acid, sodio-camphor-nitronate, and nitro-camphor.

The d-tartrate, d-camphor-sulphonate of the complex have been prepared and fractionally crystallised. On removal of the active residue, however, the resulting solution becomes inactive.

Using sodium camphor-nitronate and nitro-camphor positive results have been obtained and the *d*- and *l*-varieties of the chloride, bromide, iodide and sulphate have been obtained. The solutions, however, become racemic on keeping.

Further work is in progress.

24. Mutarotation. Part I.—Turmerol.

BIJOOR SANJIVA RAO, Bangalore.

The rate of transformation of the turmerol alone and of its solutions in alcohol and glacial acetic acid has been studied. An explanation for the change has been offered.

25. Mutarotation. Part II.—Mono- and bicyclic terpenes.

BIJOOR SANJIVA RAO, Bangalore.

The change in rotation, following the changes due to oxidation in these compounds, have been recorded. To decide, if the change in rotation is due entirely to oxidation effects, the optical activity of samples, in which oxidation and polymerisation changes have been nearly inhibited, is being studied.

26. Studies in Walden inversion. Part I.

V. ANNA RAO and P. C. GUHA, Bangalore.

Cec. L. Horton's rule (*Chem. News*, 1913, 108, 37), which claims to predict the direction of reaction in Walden inversion processes from the number of free carboxyls present in any compound, has been tested with reference to a large number of known cases and the following facts brought to light :—

- (a) Horton has overlooked about one hundred cases then known, taking only twenty-six examples as the basis of his rule.
- (b) There are about forty exceptions among approximately one hundred and forty cases.
- (c) There are several errors arising out of attempts to determine the direction of reaction in Walden inversion processes on the basis of change of *sign* of the active products.
- (d) So far as the successive use of certain reagents to produce either the original acid or its enantiomorph is considered (e.g. NOBr and NH₄OH, etc.), the available data go definitely against his generalisation.

27. Studies in Walden inversion. Part II.

V. ANNA RAO and P. C. GUHA, Bangalore.

Attempts have been made to convert *meso*-tartaric acid into one of the active varieties of tartaric acid by the application of Walden inversion process to only one of its asymmetric centres. The reverse process, viz. the conversion of *dl*- β -chloromalic acid into *meso*-tartaric acid is known and is evidently due to Walden inversion taking place in one-half of the molecule. Successive halogenation and hydroxylation of *meso*-tartaric acid and its mono- and di-ethyl esters have furnished interesting results and thrown additional light on Horton's generalisation.

28. On asymmetric synthesis of organic sulphur compounds. Part II.

V. C. PAREKH and P. C. GUHA, Bangalore.

In continuation of the work reported last year (*Indian Science Congress*, 1932, Abstract No. 130, Section of Chemistry) attempts have

been made to achieve asymmetric synthesis of organic sulphur compounds by condensing menthyl- β -bromopropionate with propyl-methyl-sulphide, and butyl-methyl-sulphide, but the resulting products, on being freed from the active menthyl group by hydrolysis, have been found to be inactive.

29. Studies in abnormal optical rotation. Parts VI and VII.

M. S. KOTNIS, BIJOOR SANJIVA RAO, and P. C. GUHA,
Bangalore.

Camphoryl-mustard oil and camphor quinone have been condensed with carbo-, oxalyl-, malonyl-, succinyl-, glutaryl-, and adipyl-dihydrazides and meta- and para-phthalyl-dihydrazides and optical activity of the products obtained has been studied in a few solvents. The effect of the carbonyl group, methylene group, and the benzene ring on the optical activity in this series of compounds has been determined.

30. Rotatory dispersion in the terpene series. Part II.

R. PADMANABHAN and S. K. K. JATKAR, Bangalore.

In continuation of previous work, the following substances have been prepared pure and their rotatory dispersion measured in the ultra-violet: (1) d-pinene, (2) d-limonene, (3) d- Δ_3 -carene, (4) d- Δ_4 -carene, (5) d- α -thujene, (6) d-sabinene, (7) l-camphene. It has been found that the optical rotation can be measured as far as $\lambda 3000$ when a thickness of 2.5 cm. of the pure liquid is employed. From the results obtained, it has been found that (1) limonene and pinene possess simple rotatory dispersion, (2) Δ_3 -carene, Δ_4 -carene and α -thujene possess complex dispersion, (3) sabinene and camphene possess anomalous dispersion. The anomaly for these two substances can be satisfactorily explained by the theory of induced asymmetry put forward by Lowry and Walker and appears to be due to the occurrence of a semi-cyclic double bond in close proximity to the asymmetric carbon atom.

31. Geometrical inversion in light. Part II.—Inversion of bromo-cinnamic acids.

B. K. VAIDYA, Bangalore.

Quantum efficiency measurements of the mutual inversion of the *cis*- and the *trans*-forms of α and $\alpha\beta$ -bromo-cinnamic acids in aqueous solutions, in radiations of $313\mu\mu$ and $253\mu\mu$ wavelengths have been carried out. In presence of light an equilibrium is established in the system with about 85–90 per cent. of the *cis*-form. Small variations have been observed with change in concentration. The kinetics of the change indicate that the reaction is of zero order and the rate is proportional to the light intensity. The quantum efficiency for the *trans* \rightarrow *cis* change is in the neighbourhood of unity, while for the reverse change the efficiency is very low. In the *cis*-form slight decomposition into carbon dioxide and bromostyrene has been observed.

Physical measurements of the heat of formation, electrical moment, Raman spectra and photochemical activity indicate that the energy content of a *cis* molecule is relatively greater than the corresponding *trans*-form, and thus, there being no higher energy level which is stable, excitation by light either causes a decomposition of the *cis*-molecule or brings about a partial conversion into the *trans*-form by means of collisions of the second kind.

32. Studies on the dependence of optical rotatory power on chemical constitution. Part XVIII.—Stereoisomeric aminoanilino-, and aminodimethylanilino-, methylenecamphors and their derivatives.

BAWA KARTAR SINGH and BHUTNATH BHADURI, Cuttack.

Aminoanilinomethylenecamphors (*m* and *p*) have been prepared by hydrolysing the condensation products of aminoacetanilides (*m* and *p*) with oxymethylenecamphors (*d*, *l*, *dl*). *p*-Aminodimethylaniline has also been condensed with oxymethylenecamphor. The rotations of these compounds are, without exception, found to obey the simple dispersion law of Drude,

$$[\alpha] = \frac{k}{\lambda^2 - \lambda_0^2}$$

In the investigations of the effect of constitution on the rotatory power, much difficulty is often met with if we confine the comparison to a particular wavelength. For the compounds which exhibit *simple* dispersion, we may overcome this difficulty by comparing the values of the *absolute* specific rotation of the compounds which are numerically equal to *k*'s of the Drude equation when

$$\lambda = \sqrt{\lambda_0^2 + 1}$$

(always in the infra-red region); λ_0 's being the absorption bands of the particular compounds.

From such a study we notice that the *polar* effect of a substituent group is traceable in the optical activity of these compounds. Substituent influence of the different groups in order of decreasing rotatory power is represented by, $\text{NH}_2 > \text{N}(\text{CH}_3)_2 > \text{H} > \text{CH}_3 > \text{Cl} > \text{Br} > \text{I}$, which agrees well, subject to minor variations, with the *polar* series as well as with the dissociation constant one of the substituted anilines, with which oxymethylenecamphor is condensed to get the present series of compounds.

The *solvent* and *position isomerism* effects on optical activity are also discussed.

33. Studies on the dependence of optical rotatory power on chemical constitution. Part XIX.—Stereoisomeric xyloidinomethylenecamphors.

BAWA KARTAR SINGH and BHUTNATH BHADURI, Cuttack.

The optically active (*d* and *l*) xyloidinomethylenecamphors (*m* and *p*) have identical rotation and are found to obey the *simple* dispersion law of Drude

It was anticipated that the further introduction of any group (such as CH_3) having a polarity similar to the one (in the present case, CH_3) already in the nucleus, will supplement the effect of the latter; (in this case) will lower the rotation of the parent compound.

From a study of the values of the *absolute* specific rotation of the compounds, we get the following expected sequence of decreasing optical

rotatory power: $\text{H} > \text{CH}_3 > \begin{matrix} \text{CH}_3 \\ < \\ \text{CH}_3 \end{matrix}$ which agrees exactly with the

specific inductive capacity series and the dissociation constant of one of the condensed bases: and thus the analogy between the effect of substitution on optical activity and on other electrophysical properties to which attention has been already drawn by Betti, Perkin, Rule and ourselves in previous communications, is further experimentally confirmed.

34. Studies on the dependence of optical rotatory power on chemical constitution. Part XX.—The rotatory dispersion of stereoisomeric hydroxyphenylaminomethylenecamphors and their acetylated and benzoyleated derivatives.

BAWA KARTAR SINGH and SAILESH CHANDRA SEN, Cuttack.

Amido-phenols (*o*, *m*, *p*) have been condensed with oxymethylenecamphors (*d*, *l*, *dl*). The rotatory dispersion of the optically active isomerides (*d*, *l*) are found to be identical and can be expressed by the simple dispersion equation of Drude,

$$[\alpha] = \frac{k}{\lambda^2 - \lambda_0^2}.$$

The replacement of a hydrogen atom by a negative group such as hydroxyl (OH) diminishes the rotation. The effect of substitution on optical activity is represented by the series which agrees subject to minor variations with the *polar* one. The acetylation and benzoyleation of the OH group reduces the rotation of the parent compound. The influences of the solvent and of the position isomerism on the rotatory power are also discussed.

35. Studies in steric hindrance. Part II.—The isomerism of the monomethyl esters of 3-bromo-phthalic acid.

P. RAMASWAMI AYYAR, Bangalore.

The preparation of 3-bromo-phthalic acid in good yield from Naphthalene for the above purpose is under investigation as follows:—

(i) Naphthalene→. (ii) I-nitro-Naphthalene→. (iii) I-nitro-bromo-Naphthalene→. (iv) I-amino-bromo-Naphthalene→. (v) Bromo-phthalic acid.

The product in stage (iii) is found to be mainly I-nitro-5-bromo-Naphthalene along with a small quantity of I-nitro-8-bromo-compound.

The direct bromination of phthalic anhydride is also being studied for the same purpose.

Further work is similar to methods adopted in Part I (*Indian Science Congress*, 1932, *Chemistry Abstracts*, No. 144).

36. Some derivatives of nitroisobutylglycerin (2-nitro-2-methylol-propandiol-1.3): I.—The trichloride and the tribromide.

KANTILAL CHHAGANLAL PANDYA, Agra.

Nitromethane, prepared by Steinkopf (Steinkopf, *Kirchhoff*, *Ber.* 1909, 42, 3439) and Wahl (*Bull. Soc. Chim.* 1909, [4], 5, 180), was condensed with formaldehyde, in the presence of potassium bicarbonate, as described by Henry (*Bull. Soc. Chim.* 3, 13, 1001). The nitroisobutylglycerin came out in crystals on keeping the reaction product in a vacuum desiccator. The nitro-alcohol was purified by recrystallisation and had all the characteristics described by Henry, including the m.p., which was 156-157°C. (Henry, 158°-159°).

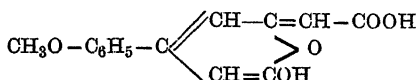
Several methods were tried for the preparation of the trichloride, of which all failed except two. The first involved the use of phosphorus pentachloride, which, however, gave small yield. Thionyl chloride in the presence of pyridine (Darzens, *C. r.* 1911, 152, 1314) and with some special modifications gave a theoretical yield. The nitroisobutylglyceryltrichloride could be purified by sublimation or by recrystallisation from warm chloroform. It melted at 107°-108°C. Analysis confirmed its identity.

The tribromide was obtained in varying but small yields by means of phosphorus tribromide in a sealed tube as well as in a flask. On purifying it gave a m.p. 89°C. Whenever the reaction mixture was heated above a certain range, decomposition accompanied by flames and large volume of black smoke and lachrymetric fumes invariably took place. Analysis confirmed identity.

37. Action of acetic anhydride and sodium acetate on anhydrides of β -aryl-glutaconic acids: formation of β -aryl-glutaconyl-acetic acids.

D. B. LIMAYE and V. M. BHAVE, Poona.

The β (4-methoxy-phenyl)-glutaconic anhydride described by us in the *Journal of the Indian Chemical Society*, 1931, 8, 137, was treated with acetic anhydride and sodium acetate for acetylating the hydroxy group. However, instead of the expected neutral acetyl derivative the anhydride gave the enolic form of β (4-methoxy-phenyl) glutaconyl-acetic acid



melting at 132° (corresponding keto form melts at 180°), a reaction similar to the Gabriel's reaction for the preparation of phthalyl-acetic acid from phthalic anhydride and also not inconsistent with the hydroxy structure suggested by Thorpe for β -aryl-glutaconic anhydrides. This enolic acid (m.p. 132°) gave a strong coloration with Ferric chloride. On loss of one mol. of CO_2 , it gave the lactone β (4-methoxy-phenyl)-methyleneglutaconide (m.p. 112°).

This lactone as well as the original acid, on alkali treatment, gave β (4-methoxy-phenyl)- γ -aceto-vinylacetic acid (m.p. 125°). This vinyl-acetic acid lost a mol. of CO_2 and gave 4-methoxy- α -methyl-benzylidene acetone, which on mild oxidation gave the known 4-methoxy- β -methyl-cinnamic acid (m.p. 152°). Also on reduction with sodium amalgam, the above vinylacetic acid gave β (4-methoxy-phenyl)- γ -aceto-butyric acid (m.p. 104°), a known compound.

The reaction was also extended to the anhydrides of (1) β (4-methoxy-3-methyl-phenyl), (2) β (2-methoxy-5-methyl-phenyl)-, (3) β (phenyl)-, (4) β (2-methoxy-4-methyl-phenyl)-, and (5) β (2-methoxy-phenyl)-glutaconic acids, with similar results.

38. Nitration. Part V.—Simultaneous nitration and oxidation of m- and p-xylenes.

P. S. VARMA and R. K. SOBTI, Benares.

Systematic investigation of the nitration of m- and p-xylenes has been made by using different nitrating agents under different conditions. It has been possible to get nitro-xylenes along with more or less quantity of nitro-toluic acids. The conditions under which the better yield of one or the other of the products is obtained have been studied to some extent.

39. Nitration. Part VI.—Nitration of benzene in presence of Bromine and Iodine.

P. S. VARMA and A. K. CHAKRAVARTY, Benares.

In a communication from this laboratory (Varma and Kulkarni, *Jour. Amer. Chem. Soc.*, XLVII, 1925, 143) it was stated that a trace of iodine catalytically favours the formation of di-nitro-benzene by the

action of a mixture of nitro-sulphonic and fuming nitric acids on benzene. It has been possible to investigate this problem further and find out if iodine or bromine has got any influence on the nitration of benzene. A number of experiments have been carried on which show that bromine and iodine increase the yield of nitro-benzene when the amount of sulphuric acid in the nitrating mixture does not fall below a certain limit. If the amount of sulphuric acid is less than a certain limit, bromine fails to affect the yield, whereas iodine decreases the yield of the nitro compound.

40. Halogenation. Part XII.—Bromination of pseudo-cumene and para-cymene.

P. S. VARMA and D. N. SEN GUPTA, Benares.

An exhaustive study of the bromination of pseudo-cumene and para-cymene has been made. In the case of pseudo-cumene, mono-, di- and tri-nuclear substituted compounds are obtained in the dark. In the diffused daylight, nearly the same products are obtained as those in the dark. In direct sunlight, however, only side-chain substitution takes place. If the reaction is carried on a water bath, only mono substitution takes place, whereas if the reaction is carried on a paraffin bath at about the temperature of the boiling point of pseudo-cumene, di- and tri-derivatives are obtained. It is very interesting to observe that under the conditions in which only side-chain substitution takes place in the case of pseudo-cumene, if mono-bromo-pseudo-cumene is subjected to bromination, only nuclear substituted derivatives are obtained. Bromination has also been carried on in presence of a number of other substances, such as sulphuric acid (strong and fuming), nitric acid (strong and fuming), a mixture of sulphuric and nitric acids, and a mixture of nitro-sulphonic and fuming nitric acids. Fuming sulphuric acid gives a good yield of the nuclear substituted derivatives. The best yield of the nuclear substituted derivatives is, however, obtained by using a mixture of nitro-sulphonic and fuming nitric acids.

41. Halogenation. Part XIII.—Bromination and iodination of benzo-nitrile.

P. S. VARMA and N. B. SEN GUPTA, Benares.

Bromination and iodination of benzo-nitrile have been studied more systematically as a result of which a number of bromo- and iodo-derivatives have been obtained. These derivatives have been obtained before by indirect methods only. In addition to these bromo- and iodo-derivatives, benzoic acid and benzamide are the other products obtained. Attempts have been made to find out the conditions under which the maximum yield of the halogen derivatives could be obtained.

42. Halogenation. Part XIV.—Bromination of m-xylene.

P. S. VARMA and R. K. SOBTI, Benares.

Bromination of m-xylene in presence of halogen carriers, such as iron, aluminium, iodine, sulphur, selenium, aluminium chloride, and iron chloride, in (1) direct sunlight, (2) diffused daylight, and in (3) dark, has been studied. The products obtained are, to some extent, different under the latter conditions. In the case of direct sunlight and diffused daylight, both the nuclear as well as the side-chain substitution takes place, whereas in the dark only the nuclear substitution takes place. It has been possible to find out the conditions that would give the maximum yield of the nuclear or the side-chain derivatives.

43. Halogenation. Part XV.—Chlorination of benzene in presence of halogen carriers and sunlight.

P. S. VARMA and A. K. CHAKRAVARTY, Benares.

A number of experiments have been carried on in which benzene and chlorine have been kept for different lengths of time in contact with a number of substances, such as pyridine, aluminium-mercury couple, aluminium powder, ferric oxide, iodine, antimony, etc., in the dark, or in diffused daylight or in direct sunlight. Very little action takes place in the dark. Some action takes place in the diffused daylight, but the action in direct sunlight is very prominent. Both addition and substitution derivatives in very good yields have been obtained. Different halogen carriers have different effect on the yield of the addition and substitution derivatives. Some halogen carriers, however, have no action at all.

44. Halogenation. Part XVI.—Bromination and iodination of ethyl benzene.

P. S. VARMA and B. RAMSUBRAMANYAM, Benares.

Bromination and iodination of ethyl benzene have been studied in the dark, in diffused daylight and in direct sunlight in the presence or the absence of halogen carriers. In the dark only nuclear substitution takes place, whereas in the diffused daylight or direct sunlight both nuclear as well as side-chain substitution takes place. By carrying on a number of experiments, it has been possible to find out the conditions, including the nature of the halogen carriers, that will give the best yield of the nuclear or the side-chain substitution derivatives.

45. Halogenation. Part XVII.—Iodination of phenanthrene.

P. S. VARMA and P. V. VISHWANATHAN, Benares.

By the study of the action of iodine on phenanthrene under different conditions, it has been possible to prepare three definite iodo-derivatives of phenanthrene. The physical as well as the chemical characteristics of these compounds have been studied. Since there is no mention of any iodo-derivative of phenanthrene in the literature, attempts are being made to find out the position of the iodine atom or atoms in the compounds obtained.

46. Derivatives of salicylic acid. Part I.

R. L. ALIMCHANDANI, N. M. SHAH, and P. K. NAVALGUND,
Dharwar.

Chattaway and Calvet (*J.C.S.*, 1928, 1090) tried the reaction of salicylic acid and chloral in presence of sulphuric acid: the product was found to be a complex mixture of substances which could not be crystallised. The present authors, thinking that this complexity may be due to the free hydroxyl group taking part in the reaction, have condensed chloral with the methyl ether of salicylic acid and have isolated a crystalline product which contains the group $-\text{CH}(\text{OH})\text{CCl}_3$, the chloral molecule attacking either *ortho* or *para* position to the $-\text{OMe}$ group. On reduction with zinc and acetic acid, the group $-\text{CH}(\text{OH})\text{CCl}_3$ changes to $-\text{CH}_2\text{CHCl}_2$. (Meldrum and Alimchandani, *J. Ind. Chem. Soc.*, 1925, 2, 1-9.) Further work is in progress.

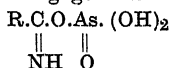
47. A study in the preparation and the properties of Organo-arsenicals by means of arsenic acid.

K. G. NAIK and K. N. CHOKSHI, Baroda.

The action of arsenic acid has been studied with the following acid amides :—

- (1) Formamide, (2) acetamide, (3) chloracetamide, (4) cyanacetamide, (5) propionamide, (6) lactamide, (7) butyramide, (8) isobutyramide, (9) valeramide, (10) isovaleramide, (11) malonamide, (12) carbamide, (13) thiocarbamide, (14) carbanilide, (15) thiocarbanilide.

The above amides, when fused with arsenic acid, reacted to give the imino-ethers of the following general constitution :—



These substances are highly soluble in water and can be crystallised from it in the form of large colourless perfectly pure crystals. Boiling with concentrated hydrochloric acid does not decompose them. Hydrogen sulphide decomposes the above compounds giving rise to arsenic sulphide. Sulphur dioxide and sodium bisulphite react with these compounds giving rise to a mixture of trioxide and pentoxide of arsenic. Alkali hydroxides decompose the above compounds with the evolution of ammonia, indicating the separation of the acid amides.

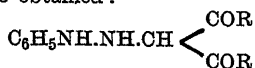
48. A study of the labile nature of the bromine atoms substituted in the reactive methylene —CH₂ group, and the effect of the negative character of the adjoining carbonyl groups, using phenyl hydrazine as the reagent.

K. G. NAIK and K. N. CHOKSHI, Baroda.

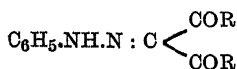
The reaction of phenylhydrazine was studied with the following compounds :—

- (1) Monobromomalonamide, (2) dibromomalonamide, (3) monobromomalon-p-bromoanilide, (4) dibromomalon-p-bromoanilide, (5) dibromomalon-2 : 4-dibromoanilide, (6) monobromomalon-p-toluidide, (7) dibromomalon-p-toluidide, (8) dibromomalon-2 bromo-p-toluidide, (9) monobromomalon-4-bromo-o-toluidide, and (10) dibromomalon-4-bromo-o-toluidide.

When the above compounds were refluxed with phenylhydrazine in presence of alcohol, compounds of the following general constitution were obtained :—



I



II

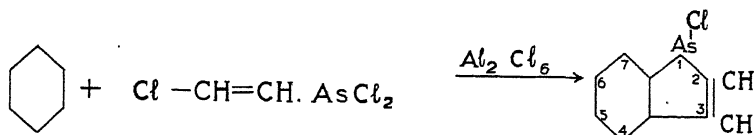
Summarising the results obtained herein, it was found that the labile nature of the bromine atoms of the methylene group in the bromo-derivatives of the amide and the substituted amides of malonic acid, increases with total increase in the negative character of the adjoining carbonyl groups, attached to the central reactive methylene group. It was also found that in the case of the dibromo derivatives, one of the bromine atoms is more reactive than the other.

Since the labile nature of the bromine atoms in the substituted methylene group is directly proportional to the reactivity of the hydrogen atoms of a reactive methylene group in compounds containing the grouping —CO.CH₂.CO—, the above conclusions are quite in a line with the views put forward from time to time since these investigations were undertaken in these laboratories.

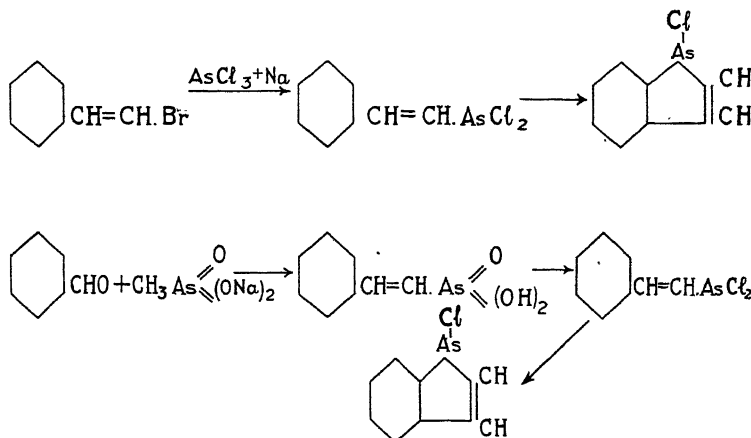
49. Studies in organo arsenic compounds.

H. N. DAS GUPTA, Calcutta.

The synthesis of Benzarsenophene chloride has been effected by the action of β -chloro-vinyl-dichloro-arsine on benzene in presence of anhydrous aluminium chloride as follows:—



The following scheme shows how the formula given to Benzarsenophene chloride has been proved to be correct.



The oxidation of Benzarsenophene chloride gives the corresponding arsenic acid derivative. The arsenic acid, on treatment with nitric acid (sp. gr. 1.5), gives the nitro-arsinic acid.

Attempts to prepare the Benzarsenophene via ortho-amino-cinnamic acid by preparing the arsenic acid derivative and then applying Fischer's method of synthesis of Indole proved futile due to the formations of tertiary arsenic oxides at the outset. (cf. *Journal Indian Chem. Soc.*, 417, 1931.)

Further work with other derivatives of the Benzarsenophene chloride are in progress.

50. Detection of aldehydes and ketones by colorimetric tests.

M. N. GOSWAMI, H. N. DAS GUPTA, and B. K. MUKHERJI, Calcutta.

The yellowish brown colour of the solution of picric acid and N/10 aqueous caustic soda is discharged by aldehydes and ketones having no adjacent $-\text{CH}_2$ group; while those containing the said grouping impart an intense red coloration.

The red colour developed by the addition of aqueous N/50 caustic soda to a solution of ortho- or meta-nitrophenol in alcohol is discharged

only by the aldehydes (both aliphatic and aromatic) and not by the ketones. Under the same condition, the yellow colour of para-nitrophenol with alkali is not affected either by the aldehydes or the ketones.

51. Preparations of sulphoarsinic acids of coumarins.

M. N. GOSWAMI and H. N. DAS GUPTA, Calcutta.

6-amino and 7-methyl-6-amino coumarins have been sulphonated by fuming sulphuric acid; the sodium salt by Bart's reaction gave the corresponding mono sulphoarsinic acids. The position of the sulphonic acid group is most probably in the benzene ring. Further work in this direction is in progress.

52. A new method of synthesising benzopyrylium compounds.

M. N. GOSWAMI and A. K. CHAKRAVORTY, Calcutta.

The compound prepared from coumarin and resorcin with POCl_3 as condensing agent (*vide Proceedings, Indian Science Congress, 1932*) has now been definitely shown to be 3': 5'-dihydroxy benzo pyrylium chloride. The identity of the di-methoxy derivative (m.p. 175°), prepared from coumarin and dimethyl resorcin with POCl_3 , with the compound (m.p. 175°) synthesised from salicylaldehyde and dimethyl resacetophenone via Robinson's method has been established. Other pyrylium compounds by the new method are being prepared.

53. Morellin.

N. C. KELKAR and B. S. RAO, Bangalore.

A methoxy derivative of morellin has been obtained (m.p. 156°). The methoxy derivative, on oxidation with alkaline permanganate, yields an acid which is being investigated.

54. Turmerol.

B. S. RAO, Bangalore.

An alcohol $\text{C}_{15}\text{H}_{22}\text{O}$ has been synthesised from curcumone and has the following constants: b.p. $143\text{--}145/6$ mm., d_{30}^{30} 0.9504, n_D^{30} 1.5062 (natural turmerol has b.p. $145\text{--}150/6$, d_{30}^{30} 0.9521, n_D^{30} 1.5115). The synthetic product gives on oxidation with permanganate an acid identical with that from natural turmerol.

55. The reactivity of dimethyldihydroresorcin. Part III.—Formation of azo dyes.

B. H. IYER and G. C. CHAKRAVARTI, Bangalore.

Dimethyldihydroresorcin behaves as a phenol towards diazotised amines and yields azo compounds of the usual type from a finally acid medium. Azo derivatives of the following amines are described, aniline, o-, m- and p-toluidines and α - and β -naphthyl amines. These dyes are either bright yellow or orange in colour.

From an alkaline medium in some cases, deep-red substances insoluble in alkali are obtained. They may be either o-azo compounds or oxydiazoles. Coupling with aminosulphonic acids is also being tried with a view to prepare some water soluble dyes.

56. Reactivity of dimethyldihydroresorcin. Part IV.—
Formation of benzylidene derivatives.

GOPAL V. NEVGI and G. C. CHAKRAVARTI, Bangalore.

Substances, containing reactive methylene groups, condense with free or substituted benzaldehydes to give benzhydrol or benzylidene derivatives. Peculiarly enough, under similar conditions dimethyl-dihydroresorcin condenses with aldehydes to give compounds of the triphenylmethane or phenylxanthene series (*J. Indian Inst. Sci.*, 1931, p. 141). By careful modification of the experimental conditions as well as by the hydrolysis of the triphenyl methane compound we have been able to obtain products in which equimolecular proportions of the reacting substances have taken part. Only the nitro-substituted compounds behave as mentioned above.

57. Reactivity of dimethyldihydroresorcin. Part V.—
Synthesis of a reduced pyridine derivative.

GOPAL V. NEVGI and G. C. CHAKRAVARTI, Bangalore.

Salicylaldehyde combines with dimethyldihydroresorcin giving o-hydroxy-benzaldimethyl-dihydroresorcin anhydride (1). Attempts to prepare the corresponding nitrogen analogue from o-aminobenzaldehyde led to the formation of 1-keto-3-dimethyl-tetrahydroacridine. The reduction of 2:7-tetramethyl-4:5-diketo-o-nitrophenyloctahydroxanthene also did not yield the desired compound (Iyer and Chakravarti, *J. Indian Inst. Sci.*, 1931, p. 157). The direct replacement, however, of the oxygen of the ring in (1), by nitrogen, by means of aqueous alcoholic ammonia, has given a product, the constitution of which is under investigation.

58. Synthesis of phenylthioxanthenes.

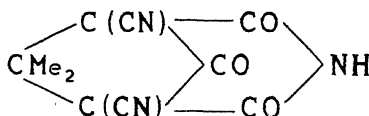
GOPAL V. NEVGI and G. C. CHAKRAVARTI, Bangalore.

In continuation of the work on the synthesis of phenyl-thioxanthenes (*vide Indian Science Congress Abstracts, Section of Chemistry*, 1932), it has been observed that, under the conditions of the reaction, oxygen derivatives of the substituted phenyl-thio-xanthenes were formed, invariably in the cases of sulphides in which the methoxy group is in the meta-position to the sulphur atom. Moreover during attempts to convert the methoxy groups into the hydroxy ones it has been observed that the former are replaced by hydrogen.

59. Studies in bridge-formation. Part I.

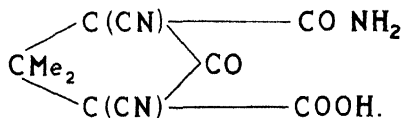
R. C. DAS GUPTA and P. C. GUHA, Bangalore.

By reacting the disodium derivative of Guareschimide with carbonylbromide two compounds have been isolated, the first one (m.p. 200°C.) of the following constitution and a second one (m.p. 233°C.) which from



the experimental evidence so far available is supposed to possess a bridged structure and is under further investigation. When the latter compound is boiled for a long time with water, a compound crystallises out and melts at 155°C.

The action of Phosgene on the sodium derivative of Guareschimide yields a very small quantity of a substance (m.p. 170°C.) which possesses the structure.



60. Attempted synthesis of cantharic acid II.

V. N. PAI and P. C. GUHA, Bangalore.

Methylation of methyl cyclohexan-1.4-dione-2.3-dicarboxylate (*Indian Science Congress Abstracts*, 1932, *Section of Chemistry*, 34) was tried using sodium methoxide in alcohol and benzene suspension under various experimental conditions. In all cases, the 2-C-methyl derivative and the dimethyl ether of methyl-4.5-dihydro-3.6-dihydroxy-phthalate were formed in varying proportions. The products of the interaction of the diketo-diester and methyl iodide in presence of sodamide in benzene suspension are under investigation.

61. Attempts towards synthesis of cantharidin.

B. H. IYER and P. C. GUHA, Bangalore.

The reaction between the disodium derivative of diacetyl-diethyl-adipate and dibromo-succinic ester (*Indian Science Congress Abstracts*, 1932, *Section of Chemistry*, No. 123) failed to give compounds having vesicant properties. Preparation of symmetrical dimethyl-dichloro-succinic acid having presented many difficulties, condensation of this with the disodium derivative of diacetyl-diethyl-adipate has been postponed.

Present attempts are progressing in the following lines. The sodium derivative of malonic ester is allowed to react with succinyl chloride. Succinyl dimalonester thus formed is separated from the accompanying succinyl malonester by preparing the disodium derivative of the former. This has been methylated using methyl iodide, but the yield is not satisfactory. Hence the sodium derivative of methyl malonic ester is being reacted with succinyl chloride to prepare 2:5-diketo-1:6-dimethyl suberate which on ring closure in positions 1 and 6 is expected to give 2:5-diketo-cantharidic acid.

62. Endo-thio triazoles and thiobiazoles.

S. L. JANNIAH and P. C. GUHA, Bangalore.

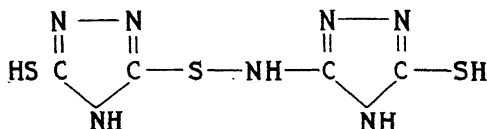
In continuation of the work reported last year, paper No. 192 of the Section of Chemistry, the following facts have been observed:—

3:5-dithio-triazole, on treatment with acetic anhydride and subsequent hydrolysis of the acetyl derivative, gave 3:5-endothio-3-thiol-1:2:4-triazole. But in the case of 3:5-dithio-4-N. phenyl-1:2:4-triazole interesting results have been obtained, viz. an interchange of positions between the S-atom and the NPh-group. Actually 3-thio-5-N. phenyl-1:2:4-thiobiazole was obtained by treating the above-mentioned triazole with concentrated hydrochloric acid, as also the endo-compound 3:5-endothio-5-phenylimino-1:2:4-thiobiazole. No such interchange of positions occurred with 3:5-dithio-1-phenyl-1:2:4-thiobiazole.

63. Action of hydrazine hydrate on persulphocyanic acid.

D. R. MEHTA and P. C. GUHA, Bangalore.

From does not give any detail about his experiments regarding the action of hydrazine hydrate upon persulphocyanic acid though he describes the isolation of two compounds, viz. hydrazine salt of 3 : 5-dithiol-1 : 2 : 4-triazole and 3 : 5-amino : thiol-1 : 2 : 4-triazole. As the result of about 15 experiments with varying quantities of hydrazine hydrate of different strength upon varying quantities of persulphocyanic acid under different experimental conditions, it has now been possible to find out the best method of preparation of both of his compounds as also a third compound melting at 252-53° which from its analytical value, molecular weight, acetyl and benzyl derivatives appears to be



Another new compound isolated in this reaction melts at 185-187° with frothing and gives the compound melting at 252-53° on being heated at 200° for two hours.

64. Ring closure of hydrazodithiodicarbonamides.

D. R. MEHTA and P. C. GUHA, Bangalore.

The action of hydrochloric acid (d, 1.19), acetic anhydride and simple heat upon monophenyl, monotolyl, monoxyl, and the corresponding disubstituted derivatives of hydrazodithio-dicarbonamides (RNH-CS-NH-NH-CS-NH₂, RNH-CS-NH-NH-CS-NHR) has been studied and a number of interesting thiazoles and triazole derivatives isolated. Several of the isolated products appear to be isomeric (endo ?) with some of the compounds of this series already known.

65. Reactions of dinitriles with aromatic hydroxyaldehydes.

N. PALIT, Patna.

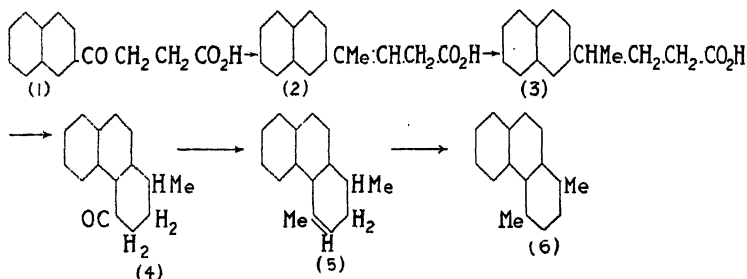
Simple aliphatic and aromatic aldehydes have been found to react with dinitriles (imido-acyl-methyl-cyanides) to form 3 : 5 dicyano-pyridine derivatives from one molecule of the aldehyde and two molecules of the dinitrile with the elimination of a molecule each of water and ammonia (E. V. Meyer, *J. Pr. Chem.*, 39. 262-83; *Chem. Zentr.*, 1908, 591-94). In the present investigation aromatic hydroxyaldehydes were employed to see if the presence of the additional hydroxyl group modify the above general course. It was expected with the ortho compound that the dinitrile might also react in the tautomeric amido form in which case one molecule of each would react to give 3-cyanquinoline derivatives in the same way as o-aminobenzaldehyde and ortho amino-acetophenone react with it. It was found, however, that the reaction did not go in this way at all. The general course of the formation of 3 : 5 dicyano-pyridines was reproduced in most cases while with salicylaldehyde the principal reaction undertook an entirely different course (Mohr, *J. Pr. Chem.*, 1897, 124). In this case, curiously enough, two molecules of the aldehyde reacted with one molecule of the dinitrile with the elimination of two molecules of water. The crystalline product is insoluble in alkali, stable

towards hydrochloric acid and has no aldehyde group. It forms a mono-acetyl derivative very easily and a trioxysterivative is obtained on hydrolysis with HCl under pressure. The author has reasons to believe that it is a xanthoquinoline derivative. Further work is in progress to elucidate its composition.

66. Synthesis of 1:4-dimethyl-phenanthrene.

S. C. SEN GUPTA, Calcutta.

β -2-Naphthoyl-propionic acid (1) is prepared from naphthalene and succinic anhydride in presence of aluminium chloride (*J.C.S.*, 1932, 1128), the methyl ester (b.p. $215^{\circ}/7\text{mm.}$, m.p. $74-75^{\circ}$) of the acid (1) is treated with methyl-magnesium iodide giving the unsaturated acid λ -(2 naphthyl)- $\Delta\beta$ -pentenoic acid (2) (m.p. $131-133^{\circ}$). This unsaturated acid was reduced with hydriodic acid (d 1.7) and red phosphorus giving the saturated acid (3), which on treatment with sulphuric acid gives 4-keto-1-methyl-1:2:3:4-tetrahydro-phenanthrene (4) (b.p. $165-170^{\circ}/6\text{mm.}$, semi-carbazone m.p. $203-204^{\circ}$). This was next treated with methyl-magnesium iodide and the product (5) on dehydrogenation with selenium at $300^{\circ}-340^{\circ}$ gives 1:4 dimethyl-phenanthrene (6) (m.p. 77°). The picrate melts at 155° .

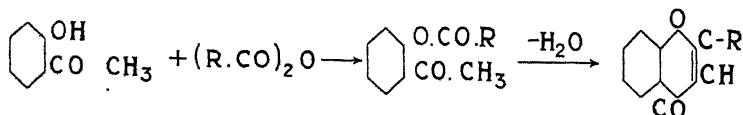


67. Studies in the Robinson reaction for the synthesis of chromones.

T. C. CHADDHA and K. VENKATARAMAN, Lahore.

Having studied the application of the Robinson method for the synthesis of chromones to gallacetophenone, 1-acetyl-2-naphthol, 2-acetyl-1-naphthol and 4:6-diacetylresorcinol (*J. Chem. Soc.*, 1929, 1931, 1932), the reaction has now been extended to o-hydroxyacetophenone, 2:5-dihydroxyacetophenone and 2:4:5-trihydroxyacetophenone. The colour reactions and dyeing properties of the new polyhydroxy-flavones thus prepared are recorded.

Attention has also been directed to the mechanism of the reaction. It has usually been assumed to proceed in two stages as follows (cf., Wittig, *Ann.*, 1924):



We have attempted the ring closure of the acetate and the benzoate of 2-acetyl-1-naphthol and of the acetate of 2-phenylacetyl-1-naphthol by means of each of the following reagents: the corresponding sodium salts, zinc chloride, phosphorus pentoxide in xylene, acetic anhydride,

and phosphorus oxychloride in chloroform. In no case could a chromone be isolated.

Contrary to Wittig (*loc. cit.*), the action of acid anhydrides on ω bromo-ketones (such as ω -chlorogallacetophenone and 2-bromacetyl-1-naphthol) has not led to chromonols.

68. A synthesis of 4-styrylcoumarins.

H. S. MAHAL and K. VENKATARAMAN, Lahore.

4-Styrylcoumarins have been made by treatment of o-hydroxy-phenyl styryl ketones (o-hydroxychalkones) with sodium phenylacetate and acetic anhydride. The following 4-styrylcoumarins were thus prepared: 3-phenyl-4-styrylcoumarin, 3-phenyl-4'-methoxy-4-styrylcoumarin, 3-phenyl-3' : 4'-methylenedioxy-4-styrylcoumarin, 3-phenyl-7 : 8 : 4'-trimethoxy-4-styrylcoumarin, 3-phenyl-7 : 8-dimethoxy-3' : 4'-methylenedioxy-4-styrylcoumarin, 3-phenyl-4-styryl-1 : 2- α -naphthapyrone, 3-phenyl-4'-methoxy-4-styryl-1 : 2- α -naphthapyrone and 3-phenyl-3' : 4'-methylenedioxy-4-styryl-1 : 2- α -naphthapyrone. 4-Styrylcoumarins unsubstituted in the 3-position could not be prepared by this method, the action of acetic anhydride and sodium acetate on o-hydroxychalkones leading only to the acetyl derivatives. 4-Styrylcoumarins have previously been made by Dey and Row (*J. Ind. Chem. Soc.*, 1924) by condensing coumaryl-4-acetic acids with aldehydes.

69. 2-Styrylchromones.

K. C. GULATI, S. R. SETH, and K. VENKATARAMAN, Lahore.

In extension of previous work (Cheema, Gulati and Venkataraman, *J. Chem. Soc.*, 1932) and with the object of elucidating the constitution of pratensol and fukugetin, the synthesis of styrylchromones derived from resacetophenone and phloracetophenone has been undertaken. On account of the difficulties attending the demethylation of styrylchromones, hydroxyl groups were initially protected by benzylation. Benzylation of resacetophenone under prescribed conditions yielded resacetophenone 4-benzyl ether, which was treated with ethyl acetate and sodium. Ring closure was effected in the usual manner and the 7-benzylloxy-2-methylchromone was then condensed with benzaldehyde and p-benzylloxybenzaldehyde respectively. Debenzylation with acetic and hydrochloric acids led to 7-hydroxy-2-styrylchromone and 7 : 4'-dihydroxy-2-styrylchromone. Similar work on derivatives of phloracetophenone is in progress.

70. An attempted new synthesis of oxy-protoberberine and a synthesis of 3-methoxy-oxy-protoberberine.

S. N. CHAKRAVARTI and A. P. MADHAVAN NAIR, Chidambaram.

Phthalide-carboxylic acid-chloride was condensed with β -phenylethylamine, when phthalide-carboxy- β -phenylethylamide (m.p. 155°) was formed. Attempts to convert the amide into oxyprotoberberine were unsuccessful. With phosphorus pentachloride as the cyclising agent a crystalline substance (m.p. 153°) was obtained.

The acid chloride of Phthalide-carboxylic acid readily condensed with β -m-methoxy-phenylethylamine, giving phthalide-carboxy- β -m-methoxy-phenylethylamide (m.p. 105°). When this was heated with phosphorus oxychloride and the product decomposed with ice, a basic substance separated, which on reduction with Zinc dust and acetic acid, converted into 3-methoxy-oxyprotoberberine (m.p. 143°).

71. A new synthesis of 3:10-dimethoxy-tetrahydroprotoberberine.

S. N. CHAKRAVARTI, N. A. VAIDYANATHAN, and A. VENKATASUBBAN, Chidambaram.

β -m-methoxy-phenylethylamine and p-methoxy-phenyl-acetic acid, prepared by improved methods, were condensed together. P-methoxy-phenyl-aceto- β -m-methoxy-phenyl-ethylamide (m.p. 85°), thus obtained, was converted in a yield of more than 80% into 6-methoxy-1 (4'-methoxy-benzyl) 3 : 4-dihydro-isoquinoline. The base readily forms a hydrochloride and a picrate, and oxidizes readily on exposure to air and is readily reduced to 6-methoxy-1 (4'-methoxy-benzyl)-1 : 2 : 3 : 4-tetrahydro-isoquinoline, a base yielding a crystalline sulphate and picrate. The base was converted into N-formyl derivative, and the latter converted into 3 : 10-dimethoxy-dihydroprotoberberine, in a yield of about 20%, which was reduced to 3 : 10-dimethoxy-tetrahydroprotoberberine (m.p. 139°).

72. Oxazine dye derived from 7-oxy-quinoline.

R. N. SEN and G. MUKHERJEE, Calcutta.

7-oxy-quinoline, which is analogous to β -naphthol, condenses with p-nitroso-dimethyl-aniline hydrochloride in absolute alcoholic solution in presence of zinc chloride and fuming hydrochloric acid on the water bath producing a violet dye analogous to Meldola's Blue.

73. Azo-triphenyl-methane and azo-pyrone dyes (ortho-series).

R. N. SEN and S. N. ROY, Calcutta.

Ortho-azo-aldehydes, prepared for the first time by coupling m-hydroxy-benzaldehyde with diazotised anilines, e.g. P-toluidine, o-, m-, and p-nitranilines and α -naphthyl-amine, have offered an opportunity of studying the azo-triphenyl-methane and azo-pyrone dyes, containing the azo and the triphenyl-carbinol chromophores in the ortho-positions, and of comparing the effect of the two chromophores in the ortho-positions with their effect in the para-positions (Green and Sen, *J.C.S.*, 1912, 101, 1113; Sen and Sett, *J.A.C.S.*, 1924, 46, 111; Dutta, *J.C.S.*, 1926, 129, 1171) and in the meta-positions (Sen and Ghosh, *J.I.C.S.*, 1928, 5, 487; Dutt, *J.C.S.*, 1926, 129, 1171).

From a study of the various azo-triphenyl-methane dyes (prepared by condensing the aldehydes with dimethylaniline and o-cresotinic acid) and the azo-pyrone dyes (prepared by condensing the aldehydes with resorcinol, pyrogallol and diethyl-m-amino-phenol) it has been observed that the introduction of an azo-group in the ortho-position to the central carbon atom, is generally attended with an increase in the depth of colour, much less than in the case of p-compounds and almost similar to that of the m-compounds.

A marked difference between the azo-triphenyl methane dyes of the para- and the ortho-series is that the yellow shade on wool produced by the leuco-o-cresotinic acid compound of the p-series changes from yellow through maroon to dark green and black by after-chroming and the carbinols are remarkably polygenetic (Green and Sen, *loc. cit.*), but the yellow shade produced by the corresponding leuco-compounds in ortho-series changes only to dirty-brown on similar treatment, and the carbinols are only feebly polygenetic; and in these respects they are more akin to the corresponding compounds of the m-series (Sen and Ghosh, *loc. cit.*).

74. Dyes derived from acenaphthenequinone. Part IV.

S. K. GUHA, Patna.

Extending the work of Sircar and Guha (*J. Chem. Soc.*, 1924, 125, 335), Guha (*J. Chem. Soc.*, 1931, 582) and Guha (Part III.—in course of publication in *J. Ind. Chem. Soc.*, 1932), the author with a view to study the tinctorial properties of azines having acenaphthene nucleus on both sides of the azine ring prepared Acenaphtha-, acenaphtha-3-chloro-, acenaphtha-3-bromo-, Acenaphtha-3 : 4-dinitro-acenaphthazine. Studies in their properties have been undertaken.

75. Dyes derived from isatin.

S. K. GUHA and H. P. BASU MULLICK, Patna.

In view of the interesting tinctorial properties of acenaphtha-phenazines containing a 'NO₂' group in the benzenoid part of the molecule and that of acenaphtha-acenaphthazine and its derivatives (*loc. cit.*) work has been undertaken to prepare similar azines in the isatin series. The compounds obtained up till now are 4'-nitro-, 5 : 4'-dinitro-, 5 : 7 : 4'-trinitro-, 5 : 7-dinitro-indophenazine, acenaphtha-, acenaphtha-5 : 7-dinitro-indazines. Work in this line is in progress.

76. Substantive cotton dyes from fluorenone.

A. C. SIRCAR and K. C. BHATTACHARYYA, Calcutta.

The paper deals with the preparation and properties of substantive cotton dyes obtained by coupling tetrazotised 2 : 7-diamino-fluorenone with various phenols and amines, such as phenol, resorcinol, salicylic acid, β -naphthol, 2-hydroxy-3-naphtholic acid, 1-naphthylamine-4-sulphonic acid, 1-naphthol-4-sulphonic acid, R-acid, G-acid, Cleve's acid, Lawrant's acid, H-acid, Y-acid, Schaffer's acid, and chromotropic acid.

77. Dyes derived from phenanthraquinone : Acenaphtheno-phenanthrazines.

P. C. DUTTA, Muzaffarpur.

It has been shown by Dutta, Prasad, and De (*J. Indian Chem. Soc.*, 1932, 9, 211) that the colour of the monoazinedyes, Phenanthraphenazines (Watson and Dutta, *J.C.S.*, 1921, 119, 1211) and Phenanthranaphthazines (Sircar and Dutt, *J.C.S.*, 1922, 121, 1944) is deepened to a certain extent with the increase in the complexity of the molecule. The present investigation was undertaken with a view to study further the above observation and it deals with azine dyes obtained by condensing various phenanthraquinone derivatives with 4 : 5-diaminoacenaphthene (Sachs and Mosebach, *Ber.*, 1911, 44, 2852).

78. Dyes derived from acenaphthenequinone and isatin : Fluoreno-acenaphthazines and fluoreno-indazines.

P. C. DUTTA, Muzaffarpur.

In continuation of the work of Dutta, Prasad and De on Fluoreno-phenanthrazines (*J. Indian Chem. Soc.*, 1932, 9, 211) the action of 1 : 2-diaminofluorene (Diels, Schill, and Tolson, *Ber.*, 1902, 35, 3284) on the aromatic o-diketones was further studied. The present communication deals with compounds produced by the condensations of diaminofluorene with acenaphthenequinone, isatin and their various derivatives. In the acenaphthenequinone series there is a distinct deepening of colour

as the nitro groups are introduced in the molecule and the shades produced on wool are deeper and much brighter than those of the Quinoxalino-acenaphthazines (Dutta and De, *Ber.*, 1931, 64, 2602), although the latter contained two azine rings. In the isatin series of course the compounds described presently, although some are highly coloured, impart lighter shade on wool than the corresponding Quinoxalino-indazines (Dutta and De, *loc. cit.*).

79. Dyes derived from quinoxalin dicarboxylic acid.

P. C. DUTTA, Muzaffarpur.

In studying the influence of nitrogen in the benzene ring on the colour and fluorescence of the phthalein dyes, it has been shown that the effect of such a nitrogen atom is to intensify the colour to a certain extent and to decrease appreciably the fluorescent property (Dutta and Tewari, *J. Indian Chem. Soc.*, 1926, 3, 161; 1927, 4, 201; De and Dutta, *Ber.*, 1931, 64, 2606).

To study further the above observations the present communication deals with phthalein dyes derived from Quinoxalin dicarboxylic acid (Hinsberg and Konig, *Ber.*, 1894, 27, 2185; *J.C.S.*, 1929, 645) by condensing with various aromatic amino and hydroxy compounds. Although the intensity of colour of these compounds was not studied quantitatively, the fluorescent property as expected has been found to be much diminished. As compared with the pyrazindicarboxyleins (De and Dutta, *loc. cit.*) the compounds described in this paper are lighter in colour presumably due to the less percentage of nitrogen.

80. Condensation of aromatic o-hydroxyaldehydes with 3-hydroxythionaphthene.

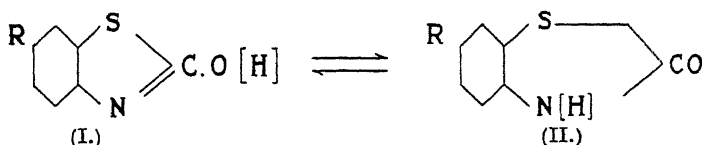
P. C. DUTTA and S. C. DE, Muzaffarpur.

The present investigation deals with pyrylium compounds obtained by condensing 3-hydroxythionaphthene with aromatic o-hydroxyaldehydes, such as Salicylaldehyde, Resorcylic aldehyde, and 2-naphthol-1-aldehyde. Condensation was brought about in two ways (1) by passing dry gaseous hydrogen chloride through a methyl-alcoholic solution of the equimolecular quantities of the constituents when the substances separated out as crystals, and (2) by first preparing the o-hydroxy-styryl ketone—an intermediate product, and converting the latter into the pyrylium salts by the action of dry hydrogen chloride. In the case of 2-naphthol-1-aldehyde, the free pyrylium chloride which is brown coloured could not be isolated, as it soon decomposed in contact with air during filtration and so the corresponding ferri-chloride and the perchlorate which are quite stable were prepared.

81. The unsaturation and tautomeric mobility of heterocyclic compounds. Part IV.—The mobility of the unsymmetrical triad system in 5-substituted-1-hydroxybenzthiazoles in relation to the ionotropic theory.

R. F. HUNTER and E. R. PARKEN, Aligarh.

Under conditions which are readily recognised as *ionising*, the 5-substituted-1-hydroxybenzthiazoles ($I \rightleftharpoons II$) exhibit exclusive reactivity in the ketodihydro form (II) towards ordinary reagents. The same alkylation and acylation products are obtained from the mobile hydroxy derivatives as from their metallic derivatives in accordance with the theory discussed in Part III (Hunter and Jones, *J. Chem. Soc.*, 1930, 2190).

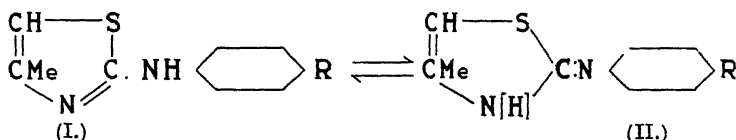


The ultra-violet absorption of mobile and static derivatives has also been examined on lines similar to those used in the case of the semi-cyclic amidines studied in Part III.

82. The unsaturation and tautomeric mobility of heterocyclic compounds. Part V.—The effect of aromatic conjugation on methylation of 2-*p*-substituted-anilinothiazole derivatives.

R. F. HUNTER and E. R. PARKEN, Aligarh.

The attraction of the aromatic nucleus on the $\alpha\beta$ -double bond in the mobile 2-anilinothiazoles ($\text{I} \rightleftharpoons \text{II}$; $\text{R} = \text{OEt}$, I , Br , Cl , NO_2) is considerably less than in the 1-anilinothiazoles (Hunter and Jones, *loc. cit.*) and these derivatives methylate exclusively in the amino aromatic form (I), giving rise to 2-phenylimino-3-methyl derivatives.

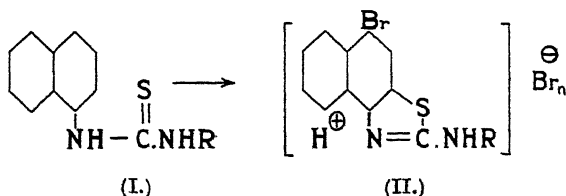


It is therefore suggested that a certain degree of aromatic character of the thiazole nucleus is lost when it is combined with a benzene ring as in benzthiazole. Since benzthiazole is a di-hetero derivative of naphthalene, this appears to constitute a further example of the mutual effect of aromatic nuclei, such as is seen in naphthalene itself, where neither of the presumably identical homocyclic carbon rings exhibits full benzenoid characteristics until the other is reduced as in the tetrahydro derivatives (Bamberger, *Annalen.*, 1890, 257, 1).

83. Studies in the Naphthathiazole series. Part I.—The constitution of the Bromo-addition compounds, of Bromo-substituted Alkylamino- β -naphthathiazoles obtained in the bromination of *s*- α -Naphthylalkylthiocarbamides. The theory of the singlet linkage in relation to the apparent expansion of Valency groups.

CHIRAG HASAN and R. F. HUNTER, Aligarh.

It has been shown that the bromo-addition compounds of bromo-substituted-2-alkylamino- β -naphthathiazoles obtained from the bromination of *s*- α -naphthylalkylthiocarbamides (I) are *hydropenta*-, *hydrotri*-, or *hydrodi*-bromides of the corresponding 8-bromonaphthathiazoles (II).



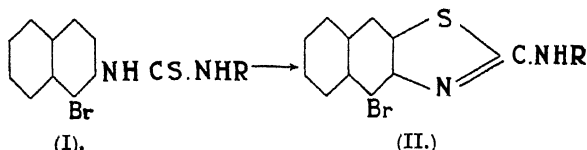
The hypopentabromides lose bromine yielding hydrotribromides, which in turn undergo degradation yielding the hydrodibromides which represent the most stable compounds of the series, despite the fact that their formulation necessitates the operation of a lone singlet linkage, such as is present in the ion $\overset{+}{\text{H}}_2$.

The formation of co-ordination compounds and the apparent expansion of valency groups such as occurs in compounds of the type of sulphur hexafluoride is discussed in the light of the theory of the single electronic link.

84. Studies in the Naphthathiazole series. Part II.—The synthesis of some derivatives of $\beta\beta$ -Naphthathiazole.

CHIRAG HASAN and R. F. HUNTER, Aligarh.

The cyclisation of the bromo-substituted- β -naphthylthiocarbamides (I) leading to the production of $\beta\beta$ -naphthathiazoles (II) examined



under conditions similar to those yield in the synthesis of 8-bromo- β -naphthathiazoles from the isomeric 4-bromo- α -naphthylthiocarbamides. The formation of the $\beta\beta$ -naphthathiazole system is accomplished with considerably more difficulty than the isomeric β -naphthathiazole system, but this is probably partly conditioned by the inhibitory effect of the bromine *ortho* to the nitrogen atom which becomes nuclear in the process (compare Dyson, George, and Hunter, *J. Chem. Soc.*, 1926, 3041; 1927, 436).

85. The chemistry of the ψ -Thiohydantoin. Part I.—The bromination of Diphenyl- ψ -thiohydantoin and its ortho-tolyl homologue.

M. OMAR FAROOQ and R. F. HUNTER, Aligarh.

It has been shown that the sulphur atom in the completely reduced thiazole nucleus in diphenyl- ψ -thiohydantoin still retains the characteristic inertness of the sulphur atom in thiophen and benzthiazole, although in this case, there can be no question of the lone electrons being required for the completion of the sextuple group, δ_6 , to which the aromatic character of such heterocyclic rings is ascribed (Armit and Robinson, *J. Chem. Soc.*, 1925, 127, 1605; Goss and Ingold, *J. Chem. Soc.*, 1928, 1268; Hunter, *J. Chem. Soc.*, 1930, 125).

86. Experiments on the synthesis of *Iso*-quinoline derivatives, Part II.

S. S. SILOOJA, K. S. NARANG, and J. N. RAY, Lahore.

It is possible that some of the minor opium alkaloids are homologues of papaverine and laudanose. Homo-laudanosines have been synthesised by the routine method and the colour reaction of some of the synthetic bases are very similar to meconidine. Direct comparison would be instituted as soon as some natural base is available. 1-methyl 3:4-dihydro-6:7-methylenedioxy-isoquinoline condenses with nitro-aldehydes to give the styryl derivatives but an ordinary aldehyde does not.

87. The constitution of Vasicine. Part II.

T. P. GHOSH, S. KRISHNA, K. S. NARANG, and J. N. RAY,
Lahore.

Further experiments on the oxidation of natural vasicine have furnished clue as to its constitution. It is 2-allyl-4-oxy-1 : 2-dihydro-quinaloline. Vasicine isomerises to a cyclic body in presence of alkali to give *iso*-vasicine. The same change takes place initially in the formation of vasicine-methiodide which is identical with the methiodide formed directly from *iso*-vasicine. *Iso*-vasicine gives an amino oxide with hydrogen peroxide. The structures of different oxidation products are discussed.

88. Experiments on the synthesis of Cyanomaclurin.

A. L. BHALLA and J. N. RAY, Lahore.

O-methoxy-2 : 4-dihydroxy-phenpriopiophenone does not smoothly pass to a flavane.

Salicylidine-acetophenone, salicylidine-2 : 4-dioxyacetophenone, 2-hydroxy-4 : 6-dimethoxy-benzilidene-2' : 4'-dimethoxy-acetophenone, are catalytically reduced to the corresponding dihydro bodies. These seem to be flavanes with a molecule of water co-ordinated at the basic oxygen atom and like cyanomaclurin are converted to amorphous bodies on treatment with hot dilute mineral acids. Therefore this route is not suitable for the synthesis of cyanomaclurin. 3 : 5 : 7 : 2' : 4'-penta-methoxy-benzopyrillium chloride (from ω -methoxy-resacetophenone-dimethyl-ether and phloroglucinaldehyde-dimethyl ether) is converted by catalytic reduction to 3 : 5 : 7 : 2' : 4'-pentamethoxy-2 : 3-dihydro flavane (dihydro-cyanomaclurin-penta-methyl ether). Identity would be established by direct comparison when some cyanomaclurin is available.

89. Studies in Chemotherapy. Part IV.

B. D. KOCHHAR and J. N. RAY, Lahore.

1-aceto-2-naphthol has been condensed with o-nitro-aromatic aldehydes. The products on reduction pass to 2'-hydroxy-naphthyl-quinolines. These are being tested for antimalarial properties because Fournieu has recently shown that a simple naphthalene derivative has antimalarial properties.

90. Studies in Chemotherapy. Part V.

K. N. KAUL and J. N. RAY, Lahore.

Further derivatives of cotarnine containing a quinoline nucleus have been synthesised for the purpose stated in the title.

91. Experiments on the synthesis of *Iso*-bergapten.

J. N. RAY, Lahore.

6-hydroxy-benzfurfurane has been converted into the corresponding o-hydroxy aldehyde. This condenses with malonic acid (in pyridin and piperidine) to give the corresponding coumarin. The product has the ring systems of *iso*-bergapten.

92. Further experiments on the synthesis of Brazilin.

J. N. RAY, Lahore.

93. The influence of attached rings on the formation and stability of heterocyclic compounds. Part III.

T. N. GHOSH, Bangalore.

In continuation of last year's work (*Proceedings Indian Science Congress, 1932, Section of Chemistry*), some aryl-carbamidopropionic acids have been prepared which, on treatment with acetic anhydride, yield oxazine derivatives. Similarly some new benzoxazine derivatives have been prepared. The evidence obtained from the action of hydrolysing agents on the above oxazine derivatives and β -lactylurea on the one hand, and benzoxazine derivatives on the other, points to the well-marked influence of the benzene ring in increasing the stability of the heterocyclic system. The remarkable stability of an eight-membered lactone ring obtained from salicylidene-anthranilic acid is attributed to the presence of two benzene rings. This behaviour of the benzene ring in helping ring-formation can be explained by the recent theory of Mills and Nixon (*J.C.S.*, 1930, 2510) which states that, round the benzene ring, adjacent valencies will be nearer where the corresponding carbon atoms are joined by a single bond.

94. Studies in heterocyclic compounds.

T. N. GHOSH, Bangalore.

By reacting o-phenylenediamine, naphthylenediamine with semicarbazides, some triazine derivatives have been obtained, the constitution of which has been discussed. The reaction of carbonylhydrazide upon o-phenylenediamine, yields an aminotriazine derivative which further reacts with carbimides to give rise to complex ring-systems. A hepta-triazine derivative has been obtained by reacting anthranilic acid with semicarbazide.

95. Studies in heterocyclic compounds.

A. C. SIRCAR and I. B. PAL, Calcutta.

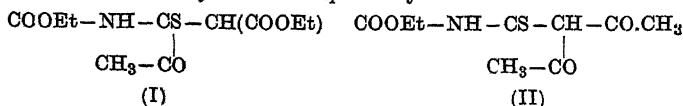
The paper describes the preparation of a number of different types of diheterocyclic compounds from α - β -diamino-quinoxaline, which already contains an azine ring the object being to study how in compounds containing two dissimilar adjacent heterocyclic rings in their molecules the properties of the different heterocyclic nuclei are affected by one another and how the properties of such compounds differ from those of the corresponding compounds in which the two heterocyclic nuclei are separated by a benzene ring.

96. New methods of synthesis of Pyridine derivatives.

T. N. GHOSH *and* P. C. GUHA, Bangalore.

(1) δ -Chloro- β -ketobutane has been prepared from β -chloro-propionylchloride and zinc-methyl iodide (Blaise and Maire *Bl.* [4], 3, 270) and its condensation with Na-urethane is being tried with the expectation that the resulting product will yield a pyridine derivative on treatment with Na-ethylate.

(2) Compounds of the types (I and II) have been synthesised by the action of carbethoxythiocarbimide on the sodium derivatives of acetoacetic ester and acetylacetone respectively.



With a view to synthesise pyridine compounds by the elimination of a molecule of alcohol, the action of Na-ethylate is being tried upon them.

97. Synthesis of Quinoline derivatives. Part I.—Extension of Beyer's synthesis of Quinoline derivatives.

D. N. MAZUMDAR, Bangalore.

Quinoline synthesis, according to Beyer's reaction, has not been studied with aromatic aldehydes and substituted amines. So a study of the same with benzaldehyde, piperonal and anisaldehyde has been made and in each case a product has been obtained though in poor yield. All these compounds respond to the ordinary tests for alkaloids.

The product obtained in the case of anisaldehyde gives a picrate m.p. 140°C. with shrinkage at 137°C.

98. Semi-micro determination of carbon and hydrogen, and nitrogen in organic substances.

B. L. MANJUNATH and S. SIDDAPPA, Bangalore.

The paper deals with the simplification of the apparatus and methods of Bobranski and Sucharda (*Sammlung Vieweg*, Heft 94, 1929). Quantities of material required are from 0.02 to 0.03g. and the average time required for analysis is about one hour and a quarter. Very accurate results have been obtained even by beginners. The paper has been communicated with the object of drawing attention to a more general adoption of semi-micro methods in regular laboratory training. Further, the introduction of such a course will serve as a valuable preliminary to micro-analytical work.

99. Quinaldinic acid as an analytical reagent. Part II.

P. R. RAY and M. K. BOSE, Calcutta.

In extension of our previous work, quinaldinic acid has been employed with excellent results for the separation of copper from phosphoric acid, manganese, nickel, cobalt, lead, arsenious and arsenic acids. Equally good results have also been obtained in the separation of zinc from manganese, calcium, barium, magnesium and phosphoric acid. The use of the reagent for the micro-detection and colorimetric estimation of iron has been described.

100. Estimation of tannin in *Cassia Auriculata*.

N. SRINIVASAN, Bangalore.

The method involves the use of the Pulfrich Refractometer for measurements of the differences between the angular positions for the extracts and their nontans. The conditions for obtaining clear extracts, and the detannisation by pure casein, have been standardised and adapted for small scale work. Within limits, the tan strengths of different solutions as obtained by evaporations are related in a simple way to the corresponding angular differences. This relationship which is being tested in low concentrations is expected to provide a rapid analytical procedure in physiological studies concerning the formation and accumulation of tannin in the bark of this plant.

101. Hydroxy-anthraquinones related to Aloe-emodin. Part I.

P. C. MITTER and SUMATICHAND BACHHWAT, Calcutta.

The acetyl derivative of 1-hydroxy-3-methyl-anthraquinone can be converted into the corresponding carboxylic acid by oxidation with

chromic acid. On treatment with thionyl chloride, the acid is converted into the chloride which on reduction with hydrogen in presence of palladiumised barium sulphate, gives the corresponding aldehyde. On deacetylation and reduction with hydrogen in presence of platinum oxide, the aldehyde is converted into 1-hydroxy-anthraquinone 3-carbinol.

102. Hydroxy-anthraquinones related to Aloe-emodin. Part II.

P. C. MITTER and S. J. DAS-GUPTA, Calcutta.

The acetyl derivative of 1-hydroxy-6-methyl anthraquinone can be converted into 1-hydroxy-anthraquinone-6-carboxylic acid, 1-hydroxy-anthraquinone-6-aldehyde and 1-hydroxy-anthraquinone-6-carbinol in the same manner as in the foregoing.

103. The Budde effect in halogens. Part I.—Chlorine.

TATA SURYANARAYANA, Bangalore.

Experiments on the action of light in pure moist and dry chlorine have been conducted, pressure changes being recorded by a highly sensitive all-glass-spring-manometer.

The following results have been obtained :—

(1) The Budde effect which is present in moist chlorine rapidly diminishes on drying the gas.

(2) The effect is most marked towards the ultra-violet and disappears altogether for light of wavelength greater than 5,000 A.U.

(3) Increase in pressure, on illumination, has been observed at different pressures, the change being approximately proportional to the pressure.

104. Period of induction in chemical reactions. Part IV.—

Action of phosphorous acid on alkali bromate and iodate.

P. NEOGI, BENOYENDRA NATH SEN, and SUDHAMOY

MUKHERJI, Calcutta.

Further work on the period of induction observed in the action of phosphorous acid on alkali bromate and iodate has been done and the results obtained are in agreement with those recorded in previous papers (Neogi and Neogi, *J.C.S.*, 1927, 131, 30 and subsequent papers) relating to the period of induction observed in the ionic reactions already studied.

105. The dissociation pressure of cadmium carbonate.

P. Y. NARAYANA, Bangalore.

The dissociation of pure cadmium carbonate has been studied by the static method in the temperature range 260–360°C. The pressure of carbon dioxide obtained can be fairly accurately represented by the equation

$$\log p = 0.014T - 5.916.$$

These values differ considerably from those of previous observers. The heat of reaction calculated by means of Nernst's equation approximates to the thermochemical value.

At lower temperatures the rate of establishment of equilibrium is very slow and the pressure appears to depend on the amount of oxide in the solid phase.

106. Theory of Liesegang phenomena by evaporation from walls.

H. P. CHOWDHURY and SATYENDRA RAY, Lucknow.

Liesegang deposits have been observed by the authors by dipping strips or blocks of tied blotting papers in red ink or inorganic salt solutions.

These phenomena under the conditions can be explained by applying an analogue of the well-known formula of heat conduction:—

$$dq = -KA \left(\frac{dc}{dx} \right) dt$$

where C=the concentration going across a section.

A periodic variation of C, the concentration, with height can be obtained by assuming the loss of water from the face exposed to the atmosphere to be proportional to the vapour pressure and therefore to the factor $(1-RC)$.

Closer or more distant rings or layers found in the Liesegang phenomena can be explained on the basis of the results thus obtained. The effect of wetting the block as well as of the humidity of the atmosphere as indicated by the theory has also been qualitatively verified.

107. The system sodium sulphite—sodium thiosulphate—water.

S. G. KIRI and K. R. KRISHNASWAMI, Bangalore.

The solubility of sodium thiosulphate in sodium sulphite solutions of various concentrations has been determined in the temperature range 21–45°, and the results obtained are discussed in the paper.

108. The activation of Indian charcoals.

L. GOPALA RAO, Bangalore.

Specimens of charcoal from eleven kinds of wood have been activated under different conditions and tested as regards their power of decolourising sugar solutions. It has been found that although the removal of mineral constituents by means of acid is an advantage, satisfactory charcoals can be obtained without the employment of this costly process. Except in one or two cases the species of wood does not have much influence on the quality of the charcoal.

A furnace for continuous activation has been constructed affording data for the design of activating plant of commercial type.

109. Adsorption of electrolytes by activated charcoal.

J. N. MUKHERJEE, S. P. ROYCHOUHDURY, and MONOMOHO
MAJUMDAR, Calcutta.

Experiments have been carried out with activated ash-free sugar charcoal. It has been shown that on washing, the charge of sugar charcoal changes from negative to zero before the charcoal ultimately acquires a positive charge. The change of charge on the surface of charcoal has been shown to be due to electrolytic impurities coming out of the charcoal surface. Adsorption of acid and alkali by the charcoal has been determined by indicator titrations and also by conductivity measurements and conductometric titrations of the supernatant liquid remaining after adsorption. The slope of the conductometric titration curves of the clear supernatant liquid shows that weak anions or cations are not present in the supernatant liquid after adsorption. It is found that on washing, the adsorption of alkali by charcoal definitely diminishes, but

that of hydrochloric acid remains unchanged. Also both negative and neutral charcoals have been found to adsorb hydrochloric acid very strongly. Sulphuric acid is, however, very slightly adsorbed. Both hydrochloric and sulphuric acids give almost the same electro-osmotic effect on negative charcoal.

110. Studies in some physico-chemical properties of gels, Part III.

N. A. YAJNIK, D. N. GOYLE, and J. D. VARMA, Lahore.

A study of the physico-chemical properties of some more gels—both of organic as well as of inorganic substances—has been continued with a view to arrive at their structure. Amongst the properties already studied by the authors, two more—(i) the relation between the time of setting and surface tension, and (ii) the double refraction of light by gels—have been included in the present investigation. Further investigations on the diffraction of X-rays by different gels is being continued.

111. Sensitivity of sols and its relation to the particle-size.

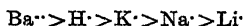
N. A. YAJNIK, D. N. GOYLE, and G. C. DANG, Lahore.

The coagulation of sols—filtered through filter papers of known porosity—by electrolytes has been studied and it has been found that the filtered sols show a more regular coagulation than the unfiltered ones. Further, the stability of the sols goes on increasing as they are filtered through finer media, other factors remaining the same.

112. Variation of the charge of colloidal particles. V—Experiments on arsenious sulphide sol in relation to the critical potential.

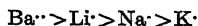
J. N. MUKHERJEE, S. P. ROYCHOUDHURY, and S. G. RAJKUMAR, Calcutta.

Cataphoretic measurements on arsenious sulphide sol have been carried out by the following electrolytes: LiCl , NaCl , KCl , HCl , BaCl_2 and As_2O_3 . From the speed concentration curves it is found that the adsorbability of the various cations by the sol is in the following order for the ascending portions of the curves:



The adsorption of Ba^{++} and H^+ ions are so strong that under no condition, that of chlorine can outweigh them and a continuous decrease in charge is observed (negative slope).

In the portions of the curves where the concentration is lower than $\cdot 01$ normal, the adsorbability of the different cations appears to be in the following order:



The curve for HCl cuts the other curves and indicates that the relative adsorbability of H^+ ion changes with concentration even within this region.

With As_2O_3 an initial increase in cataphoretic speed at $\cdot 0001$ N and at higher concentration a continuous decrease is observed.

113. Colloid chemical analysis of various samples of aluminium hydroxide sols.

S. P. ROYCHOUDHURY, Calcutta.

Colloid chemical analyses of various aluminium hydroxide sols of very low specific conductivity have been carried out. The results show that the observed specific conductivity of the sol is much less than the calculated sum of the contributions to the specific conductivity by the various ionic species (H^+ , Cl^- , $1/3 Al^{+++}$) present in the sol.

114. Replacement of adsorbed ions on the surface of activated silica gel.

P. B. GANGULY, Patna.

A specimen of silica gel was activated by the method used by Ray (*Jour. Phys. Chem.*, 1925, 29, 79). The adsorption of the positive ions from electrolyte solutions by the activated silica gel was measured in the cases of about twenty different electrolytes. In the case of monovalent electrolytes an ion of a metal of lower atomic weight can generally be replaced by that of a metal of heavier atomic weight. The extent of replacement depends on the concentration of the solution, valency of the ions and the relative weights of the adsorbed and displaced ions. The amount of adsorption as also the subsequent replacement by a heavier ion depends on the mode of formation and activation of the gel. The results have been discussed in the light of ionic replacements in soils.

115. Determination of flocculation values from measurements of the rate of coagulation of an arsenious sulphide sol.

D. N. GHOSH and P. B. GANGULY, Patna.

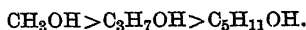
Numerous investigators have determined flocculation values from measurements of the time required for the production of a certain state of turbidity of the sol. Flocculation values thus determined are not strictly comparable as they refer to a transitory state, during the process of coagulation. It is much more important to measure the velocity of coagulation as coagulation is really a process of the progressive growth of particles. An experimental arrangement has been set up for determining the rate of coagulation of colloidal solutions by measuring the change in the intensity of the scattered beam. Flocculation values determined by the above method agreed well with the experimental measurements of Oden and Weiser.

116. Studies in ceric hydroxide sol.

MATA PRASAD and M. V. NABAR, Bombay.

The kinetics of coagulation of the ceric hydroxide sol dialysed and diluted to different extent has been studied when the sol is coagulated by different amounts of sodium and magnesium chlorides. The coagulation velocity curves are 'S' shaped for impure and the concentrated sols, and steep for the pure and the diluted ones. Smoluchowski's equation is applicable up to a certain stage of coalescence of the ceric hydroxide particles. Larger deviations are observed with pure sol and with sol coagulated with large amount of the electrolytes.

The alcohols sensitise and the sugars protect the coagulation of the sol by sodium chloride: these actions increase as the sol gets purer. The sensitising action of alcohols increases as



Cane sugar acts as a better protecting agent than any other sugar.

117. The kinetics of coagulation of titanium dioxide sol.

S. M. MEHTA and MISS OLIVE JOSEPH, Bombay.

The coagulation of titanium dioxide sol by sodium and magnesium chlorides has been studied when the sol is dialysed and diluted to different extent. The Smoluchowski's equation has been found to apply to the coagulation of titanium dioxide sol only for a limited range of the concentration of the coagulator. The coagulation velocity curves are 'S' shaped for sols dialysed up to ten days; sols dialysed for longer time do not show the auto-catalytic nature of the coagulation process. These results have been explained on Freundlich's first and second critical potential.

118. Variation of viscosity during coagulation. Part I.

S. S. JOSHI and K. S. VISHVANATH, Benares.

Progress of the coagulations of colloid arsenious sulphide by a number of KCl solutions in the range, N/16 to N/20 when the above sol was protected by 0.025% and 0.05% gelatine solutions, by BaCl₂, whose concentration was varied progressively from N/11.7 to N/10, and of 0.1% and 0.05% gelatine solutions by KCl in the range N to N/2 was studied by following the viscosity variation. It was observed that in all cases viscosity diminished to a minimum. This initial fall increases by increasing the coagulator concentration. The interval of time within which, during coagulation, the viscosity of the system lies below the initial value (that is, at the start of coagulation) increases rapidly as the coagulator concentration is reduced. Evidence has also been obtained of the existence of more than one minimum in the viscosity-time curve when very low concentrations of the coagulator were employed.

119. Variation of viscosity during coagulation. Part II.

S. S. JOSHI and T. MADHAVA MENON, Benares.

In order to obtain more information about the conditions of the viscosity diminution in the coagulating sol (cf. Part I), work was extended to coagulations in which various concentrations of each of the following electrolytes were used: KF, KCl, KBr, KI, BaCl₂, AlCl₃ and ThCl₄. For a given concentration of any of the foregoing coagulators, coagulations were studied over a wide range of the colloid concentration. It was found that the deduction made in Part I, met with an occasional exception when ThCl₄, AlCl₃ and KF were used. The magnitude of the initial fall did not show any regularity of variation in the KF, KCl, KBr and KI series. The same remark applies to the influence of varying the colloid concentration, keeping that of the coagulator constant. It can be stated in general that the viscosity-time curves show less inflexions as the concentration of the coagulator is increased. For low concentrations, evidence obtained is very appreciable to show that the corresponding process of coagulations passes through a series of successive zones of coagulation, each with a characteristic time rate for its viscosity variation.

120. Studies in the kinetics of coagulation. Part V.—The 'Wall Effect'.

S. S. JOSHI and V. LAXMI NARAYAN, Benares.

Evidence showing that the walls of the containing vessel cannot be considered as but an inert component of a colloid system was afforded (Joshi and T. Surya Narayan, *J. Indian Chem. Soc.*, 1930, 7, 883; also *Koll. Zeit.*, 1932, LIX, 335) by the observation that the characteristic

precipitation of the colloid manganese dioxide on the parchment paper during dialysis was very markedly reduced by applying a negative potential of about 200 volts to the dialysing septum. This possibility of 'wall effect' has now been examined in detail in the coagulations of manganese dioxide, antimony sulphide and ferric hydroxide sols, under a wide range of conditions. The 'wall effect' was observed by following the course of any given coagulation (a) with the normal wall area of containing vessel, and (b) when this was increased about fourfold by introducing smooth glass beads of known size, and (c) when the containing walls and beads were paraffined. A number of these coagulations were found to be autocatalytic, as judged from the rise in β with time, and the corresponding coagulation-time curve being s-shaped. The coagulation rate increased markedly and autocatalysis diminished under (b). Just the opposite was observed under (c). In general the course of coagulation becomes simplified under (b), and is assignable as belonging to the region of 'rapid' or the 'slow' coagulation as contemplated in Smoluchowsky's theory. It is considered that 'autocatalysis' is not fundamental to the process of coagulation, in general. In view of the well-known limitations of the applicability of Smoluchowsky's theory in the region of *slow* coagulation, numerous workers have suggested 'autocatalysis' as the main characteristic of slow coagulations in contradistinction to the mechanism underlying Smoluchowsky's analysis. Results obtained in this investigation show that autocatalysis can be eliminated and added on to the course of a given coagulation by manipulating factors (such as 'wall effect') not fundamental (on the existing theories at any rate of the kinetics of coagulation), to the main process. The disentanglement of a coagulation from such a factor must therefore precede its examination in respect of the applicability of Smoluchowsky's theory. It was found for example in the coagulation of ferric hydroxide sol by potassium chloride solutions that within about 50 minutes from the start of coagulation β increased by about ten times, the coagulation-time curve being markedly s-shaped, indicative of autocatalysis. That the last-named factor had masked the true course of the reaction was shown by the fact that when the same coagulation was studied with increased wall surface, the s-shape had disappeared, and concordant values for the Smoluchowsky's constant, β , were obtained.

121. Studies in the coagulation of colloids from the standpoint of Smoluchowski's theory. Part VI.

S. S. JOSHI and A. N. LAL, Benares.

It was observed in Part II (*J. Indian Chem. Soc.*, 1931, 8, 337) and Part III (*Ibid.*, 1932, 9, 157) of this series that in the *slow* coagulations of the arsenious sulphide sol by dilute sulphuric acid solutions, the departure from the requirements of Smoluchowsky's theory (as shown by the diminution in β) occurred in all the cases examined during the *initial* stages of coagulation. The following equation was used:

$$\beta = \frac{1}{t} \left[\left(\frac{n_0}{n_t} \right)^{\frac{1}{2}} - 1 \right] \quad \dots \dots \dots (i)$$

where the different symbols have their usual significance. This result is contradictory to the findings of Mukherji and Majumdar (*J. Chem. Soc.*, 1924, 125, 785), Desai (*Trans. Faraday Soc.*, 1928, 24, 191) and others who used the equation

$$\Sigma n = n_0 / 1 + \beta t \quad \dots \dots \dots (ii).$$

A study was made, therefore, of the coagulations of colloid manganese dioxide, using a different method of following the course of coagulation, viz. the change of the surface tension of the coagulating sol. It was found

that using equation (i) same results were obtained as were observed previously (*loc. cit.*). Applying equation (ii) to the same data, it was found that in agreement with the results of workers mentioned above, just the opposite was found to be the case. This apparent anomaly has been discussed in the paper from a theoretical point of view.

122. The preparation of manganese dioxide sol.

M. K. SHRINAVASAN, Benares.

In view of its well-known and characteristic instability, work was undertaken to investigate the possibility of preparing concentrated and stable sols of manganese dioxide, using glycerol, gelatine, sodium oleate, egg white and casein as protectives. For reasons explained in the paper trials with a number of concentrations of glycerol, gelatine and sodium oleate gave sols of but poor concentration. This is rather unexpected in view of the well-known strength of gelatine and sodium oleate as protectors. Best results were obtained with gum arabic and egg white (under restricted conditions of preparation detailed in the paper). The resulting sols were concentrated and what is more, could be filtered and dialysed without coagulation.

123. Studies in the protective action of colloids. Part I.— Ionic adsorption in coagulations of protected sols.

A. JOGA RAO, Benares.

A review of the literature having shown that no quantitative information was available on the subject, the present work was undertaken with a view to correlate (i) the amount of ionic adsorption with the concentration of the protective agent in the system. Arsenious sulphide sols protected by different concentrations of gelatine, sodium oleate, and starch solutions were coagulated by barium and ferric chloride solutions, the concentration of the coagulator being also varied. The amount of ionic adsorption produced was then determined analytically. Results showed in a number of cases that the adsorption on the colloid actually diminished despite an increase in the concentration of the protector. The corresponding curves also show a number of breaks which have been ascribed to the formation of adsorption complexes.

124. Studies in the protective action of colloids. Part II.— Variation of some physical properties of protected arsenious sulphide sol with the concentration of the protector.

A. JOGA RAO, Benares.

The work in Part I has been extended to a study of the (i) viscosity, (ii) turbidity, (iii) surface tension, and (iv) refractive index measurements for different values of the protector concentration. Owing to experimental difficulties results with the last two properties have not been decisive. Viscosity measurements have in the main confirmed the conclusions in Part I.

125. A new method of investigating the kinetics of alcoholysis.

S. S. JOSHI and A. JOGA RAO, Benares.

Despite the considerable amount of work which has been carried out by numerous workers on the above subject, but little quantitative information is available on the kinetics of this reaction with a few notable exceptions. The kinetics of the alcoholysis of methyl acetate by amyl,

isobutyl, and n-propyl alcohol were studied by following the viscosity variation of the mixture at two temperatures with the Scarpa type of viscometer, and also using different amounts of hydrogen chloride as a catalyst. In agreement with Kolhatker's results (*J.C.S.*, 1915, 107, 921) the reactions were found to be unimolecular, and the velocity constant proportional to the concentration of the catalyst. Interesting results were obtained when isobutyl alcohol was used at 25°C. Plotting log of concentration against time, two straight lines inclined at an angle were obtained, giving two series of values for the velocity constant. This feature disappeared when the same reaction was carried out at 30°C. Results similar to the previous case were obtained at 30°C. in the alcoholysis by normal propyl alcohol. A tentative suggestion has been made that those reactions proceed in two consecutive stages.

126. Distribution of benzoic acid between toluene and water in the presence of electrolytes.

S. S. JOSHI and K. P. HALDAR, Benares.

The distribution of benzoic acid between toluene and water was studied when the latter contained varying amounts of NaCl, KCl, BaCl₂, CaCl₂, Ce(NO₃)₄, Zr(NO₃)₄, Th(NO₃)₄, H₂SO₄, HNO₃ and HCl. It was found that *k*, the distribution coefficient, fell progressively as the amount of the electrolyte added was increased in the case of the first four salts and sulphuric acid. This diminution was exactly linear in the case of KCl. *k* remained constant with varying amounts of Ce(NO₃)₄ and Th(NO₃)₄ present in the aqueous phase. In the case of HCl and HNO₃, *k* diminished to a minimum which remained unaltered with further and large additions of the acid to the water, the value of the constant minimum being the same in both the series. Interesting results were obtained when *k* was determined with a given amount of KCl in the aqueous phase; this amount was varied for different series. It was found that with KCl, *k* increased to a maximum and then diminished. Just the reverse was the case with BaCl₂, which gave minima. It must be pointed out here that within the range of benzoic acid concentrations used, when the aqueous phase was pure water, *k* was constant. Experiments were also carried out to investigate the influence on the solubility of benzoic acid in water in the presence of the salts mentioned above. An attempt has been made to relate the above results with the ionic strength, the state of hydration of the added electrolytes, the variable ionisation of benzoic acid in the aqueous layer and its polymerisation in the toluene layer.

127. Kinetics of sucrose inversion, produced adiabatically.

S. S. JOSHI and GURUDAS R. PHANSALKER, Benares.

Arising out of some work on the energetics of sucrose inversion, it was observed that when the reaction occurred adiabatically, the heat capacity of the system being sensibly constant, fairly concordant values for the unimolecular coefficient were obtained for variously concentrated sucrose solutions, from a knowledge of the gradients of the time-temperature curves. The temperature interval was about one degree C., and the accuracy of the measurement was about 1 in 3,000. It is considered that the method is particularly useful in investigating the initial stages of a reaction.

128. Decomposition of paraffins in electric discharge.

S. S. JOSHI and SARJU PRASAD, Benares.

Thin layers of molten paraffins were subjected to ionisation by collision in fields due to continuous, and alternating (at commercial

frequencies) potentials. Under the available conditions of electric supply, the decomposition of the paraffins was more appreciable under the former conditions. The final mixture consisted principally of hydrogen, methane, acetylene, and ethylene. Data are given, when the reaction was carried out in (i) vacuum, (ii) in nitrogen, and (iii) hydrogen. The electrical conditions were varied in respect of the (i) applied voltage, (ii) the secondary current, (iii) the frequency, and (iv) the capacity introduced in the high tension circuit. All these factors were found to influence both the rate of change and the composition of the reaction mixture. The progress of the decomposition was followed by (i) the pressure-time curves, and (ii) by analyses of the mixtures at different stages of the decomposition.

129. Kinetics of the decomposition of trichloroacetic acid in aniline.

A. N. KAPPANNA and H. W. PATWARDHAN, Nagpur.

A study of the kinetics of the decomposition of trichloroacetic acid in aniline and aniline-benzene and aniline-toluene mixtures has been made. Benzene and toluene are inert so far as trichloroacetic acid decomposition is concerned. For the same concentration of the acid, the velocity of decomposition of the acid diminishes with diminution of aniline concentration in the mixtures. The results obtained, indicate that aniline molecules take part in activating the trichloroacetic acid molecule and the order of reaction, with respect to aniline, has been found to be two.

130. The photo-reduction of ferric chloride in alcoholic solutions.

MATA PRASAD and P. S. LIMAYE, Bombay.

The photo-reduction of alcoholic solutions of ferric chloride in (a) sunlight, and (b) artificial light takes place in two stages. The order of the photo-reduction in the first stage, in both the cases, is zero molecular but in the second stage, it is unimolecular in the first case and zero molecular in the second. The extinction coefficient measurements of the solutions exposed to artificial light and the conductivity measurements of solutions exposed to sunlight also show a sudden decrease in value after some time. The change in the stage of the reduction from one to the other is not due to the formation of colloidal ferric hydroxide, as it has been found to retard the reduction in both the stages. In sunlight, lower wavelengths are more active and greater reduction takes place in composite light than that in its separate constituents.

The value of the quantum efficiency for solutions of concentrations between 0.1 M. and 0.2 M. lies between 1 and 3 at 30° for radiations lying in the visible region and it increases with (i) temperature, (ii) concentration of the solution, and (iii) frequency of the incident light.

131. Note on electrical adsorption.

A. GANGULI, Chandernagore.

In a previous paper [Kar and Ganguli, *Zeit. fur. Phys.*, 61, 411 (1930); Ganguli, *Ind. Phy. Math.*, 3, 53 (1923)] Langmuir's equation was extended to derive expressions for electrical adsorption. There we assumed the simultaneous adsorption of the similarly charged ions as well. The ionic antagonism, initial increase of charge of colloidal particles, charge reversal, anomaly of the valency rule can only be explained on the assumption that besides electrostatic forces, the physico-chemical adsorption

forces are also in operation [cf. Dhar, *J.I.C.S.*, 4, 173 (1927)]. In the case of anomalous behaviour of colloidal solutions and dilution again, the adsorption of like ions must be taken into account.

Previously, we simplified the equations by neglecting the area correction. Proceeding in the rigorous manner we obtained the charge due to adsorption of uni-univalent ion

$$\eta = \frac{F}{\beta + \beta^1} \left\{ \frac{1}{1 + \frac{k_1}{c} e^{-\frac{Q_1 + F\psi}{RT}}} - \frac{1}{1 + \frac{k_2}{c} e^{-\frac{Q_2 - F\psi}{RT}}} \right\}$$

$$\text{where } k_1 = \frac{(2\pi m_1 RT)^{\frac{1}{2}}}{N h (\beta + \beta^1)} \quad \text{and} \quad k_2 = \frac{(2\pi m_2 RT)^{\frac{1}{2}}}{N h (\beta + \beta^1)}.$$

On assuming for $\eta = 0$, $\psi = 0$, we obtain the simple equation deduced before.

In order to have net electric charge we are to introduce another factor η_2 corresponding to Debye-Huckely expression for interionic attraction [cf. Muller, *Koll. Chem. Bei* 26, 274 (1928)]

$$\eta_2 = \frac{\sqrt{DRTc}}{2\pi} \left(e^{\frac{F\psi}{2RT}} - e^{-\frac{F\psi}{2RT}} \right)$$

$$\text{or} \quad \eta_0 = \eta_1 + \eta_2 = \frac{2F^2 c \psi}{kRT} + \frac{\sqrt{DRTc}}{2\pi} \frac{F\psi}{RT}.$$

From Debye's theory $\psi = -\alpha \sqrt{c}$

the electro-kinetic potential decreases as \sqrt{c} . The evaluation of ψ also involves the dielectric constant and there are controversies as to whether the dielectric constant of the bulk of the medium or that of the liquid enclosed within the double layer is to be chosen. Neglecting the effect of similarly charged ions, the effect of the valency (z_i) coagulating ions will be indicated by the exponential factor e^{-z_i} . Thus the coagulating concentrations of mono-, bi-, tri-, and tetravalent ions will be as

$$c_1 : c_2 : c_3 : c_4 = e^{-\frac{F\psi}{RT}} : e^{-\frac{2F\psi}{RT}} : e^{-\frac{3F\psi}{RT}} : e^{-\frac{4F\psi}{RT}}.$$

132. Note on adsorption of gases by solids.

A. GANGULI, Chandernagore.

In previous papers Langmuir's adsorption formulæ were derived by the author for the two cases, when an adsorbate molecule occupied (1) only one-adsorption centre, (2) n -adsorption centres. For the second case, surface dissociation of adsorbate molecules was proposed. It was shown that the maximum adsorption potential of Polanyi corresponded to the heat of adsorption. Recently London [*Z. Phys. Chem.*, 11B, 222 (1930)] has given a wave-mechanical method for calculating heat of adsorption, and it has been shown that the agreement between observed and theoretical values are obtained for mono-molecular layer. This confirms our assumption that although there is a theoretical possibility of change of adsorption potential with the distance, the value for the distance corresponding to unimolecular adsorption is of importance, i.e. the maximum adsorption potential is identical with the heat of

adsorption. The fundamental difference between Langmuir's theory and Polanyi's theory are thus more apparent than real. The adsorption forces as well as Van der Waal forces have been shown to be of similar nature as homo-polar valency.

As for the effect of temperature, recently the theory of activated adsorption has been proposed by Taylor. This has been subsequently criticised by Steacie and Ward who attribute the change of adsorption to solvent effect while Burrage considers impurities to have marked effect on adsorption.

The second postulate of Langmuir (surface dissociation) explains the change of adsorption with temperature and the theoretical values obtained by the author indicates that the value of the number of dissociated atoms as well as the degree of dissociation may affect adsorption in a remarkable manner. Further experimental work on the measurement of specific surface, study of nature of the surface, and the variation of 'n' with temperature and pressure are required for clearing up the difficulties and obtaining a true picture of adsorption.

133. Adsorption of benzoic acid from mixtures of polar and non-polar liquids.

P. G. DESAI, Bombay.

The adsorption of benzoic acid by animal charcoal from three types of the following binary mixtures was determined :—

- (1) When both the components are non-polar.
- (2) When one component is polar and the other non-polar.
- (3) When both the components are polar.

It has been found that in case (1) the adsorption-composition curves are almost straight lines while in the two remaining cases, minima are generally obtained on the adsorption-composition curves. In the mixtures studied, no case is known where a maximum is obtained on the adsorption-composition curves.

It has been shown that in most cases, where maxima are obtained on the solubility-composition curves, minima are obtained on the adsorption-composition curves.

134. Adsorption of benzoic acid from polar and non-polar liquids.

P. G. DESAI, Bombay.

The adsorption of benzoic acid by animal charcoal, zinc oxide, aluminium oxide and fuller's earth from polar and non-polar liquids was determined.

It is found that the adsorption by zinc oxide was the greatest, while that by fuller's earth was the least. It is also found that adsorption from non-polar liquids is greater than that from polar liquids. It is shown that an inverse relation exists between solubility and adsorption.

135. Effect of polar and non-polar solvents on the solubilities of cinnamic, phthalic and succinic acids.

P. G. DESAI, Bombay.

The solubilities of the three acids differing greatly in their polar character were determined in a number of polar and non-polar solvents.

It is found that the solubilities of the acids in the non-polar and slightly polar solvents are in agreement with the polar nature of the solutes. With highly polar solutes like the phthalic and succinic acids,

their solubilities in the non-polar solvents are negligible while the solubility of the less polar cinnamic acid is appreciable in the same solvents. The solubilities in the more polar alcohols were not in agreement with the polar character of the solutes.

136. Solubilities of benzoic and salicylic acids in mixtures of organic solvents.

P. G. DESAI, Bombay.

In continuation of the work (*Proceedings Indian Science Congress, 1932, Section of Chemistry*), the solubilities of the two acids were determined in some more binary mixtures. It is found that when both the components of the mixture are non-polar, the solubility composition curves are almost straight lines, whereas in the case of a mixture of chloroform with non-polar liquids, the solubility-composition curves were convex towards the composition axis. With mixtures of alcohols with non-polar solvents and nitrobenzene, the solubility increases with the addition of alcohols, reaches a maximum and then decreases. The same was found with mixtures of nitrobenzene with the non-polar liquids.

137. Viscosity of sulphuric acid solutions and hydrate formation.

BALBHADRA PRASAD, Cuttuck.

Viscosity of sulphuric acid solutions is measured at a number of concentrations. The results are shown graphically and in tabular forms. In one graph, viscosity is plotted against concentration, and in another, the rate of variation of viscosity with concentration against the corresponding concentrations. From these two graphs the existence of four hydrates: trisulphuric monohydrate, and monosulphuric half-hydrate, monohydrate and dihydrate is derived. The possible electronic configurations of the hydrates have also been suggested.

138. A critical examination of the various empirical formulæ connecting viscosity, temperature and density.

BALBHADRA PRASAD, Cuttuck.

Various formulæ have been suggested connecting the viscosity of liquids with temperature and with density by various workers. The way in which viscosity, density, and absolute temperature are connected depends on a number of factors, e.g. molecular weight, the kind of linkages in the molecule, etc. No formula is satisfactory for a number of liquids. Even in the homologous series the formula for every liquid has to be slightly different.

139. Velocity of reactions in heterogeneous systems.

D. D. KARVÉ and K. K. DOLE, Poona.

Reaction velocities in heterogeneous systems are expected to depend on a number of factors, chief among them being the extent of the surface of contact between the phases and the velocity of the diffusion of the products of reaction from these surfaces into the interior of the phases. The reaction chosen for the study of velocity was that between carbon disulphide and caustic soda in different concentrations.

If the chief product of the reaction, viz. the thiocarbonate is oxidised off as soon as it is formed, the result would be practically the same as that of diffusion into the interior of the aqueous phase. This is brought about by the addition of hydrogen peroxide and the addition of varying quantities of this substance to the reaction mixture increases the velocity in proportion to the amount and concentration.

140. On the wave statistical theory of the mechanism of chemical reactions. I.—Unimolecular reactions.

A. GANGULI, Chandernagore.

By extending a method due to Kar and the author, applied to the case of radioactive disintegration, damped wave equations have been obtained for the phase space in the configuration of the original reacting substance and introducing a potential barrier, the following expressions for the velocity coefficient have been derived

$$k_1 \sim \frac{.91}{h} \sqrt{A(A-Q)} \cdot e^{-\frac{A}{kT}} \quad \text{(First approximation)(1)}$$

$$k_1 \sim e^{\beta \frac{(Q-A)}{\sqrt{A}}} \cdot e^{-\frac{A}{RT}} \quad \text{(Large damping)(2)}$$

$$k_1 \sim c \frac{\sqrt{A(A-Q)}}{h} e^{k \sqrt{A} (U+Q-2A)} e^{-\frac{A}{kT}} \quad \text{(Small damping)(3)}$$

Here Q is the heat of reaction, ' A ' is the 'heat of activation' or the energy required to bring the molecules to a state, such that the spontaneous damping (as in the case of radioactive decomposition) may take place, or in the language of quantum mechanics, the resonance energy such that the 'anstauch' may take place between the configuration in which the molecules are present as an entity and that in which the resultant products are loosely held. In fact ' A ' then becomes identified with the internal energy of the undecomposed molecules which again is equal to that of the system in which the resultant products are loosely held. β and k are factors involving A , Q , and l the minimum distance at which attraction between the two components may exist. For $Q=0$ Equation (1) reduces to an expression similar to that obtained before by Dushman, Polanyi, and Wigner, and the author. Equation (2) is similar to that obtained by Roginsky and Rosenkewitch from wave mechanics. The variation of k , at very low pressure is accounted for as due to change in l and also the damping coefficient, since this last is affected when the density is very small. A mechanism of activation is discussed.

141. The effect of salts, emulsoids, colloids, and some organic substances on the action of diastase on starch.

P. S. VARMA and SHEONATH PRASAD, Benares.

The results obtained by the previous workers on the effect of salts on the action of diastase on starch are conflicting. Attempts have been made to study the effect of the substances mentioned above in a more systematic manner under similar experimental conditions. In certain cases, the action of diastase is increased very considerably whereas in others it is either retarded very appreciably or inhibited altogether. In the case of certain salts, the strength of the solutions of the salts used has also a considerable influence. With aluminium chloride, for example, there is almost inhibition by N/10 solution, whereas there is a considerable activation by N/100 solution.

142. Esterification equilibrium in the vapour phase.

R. V. VALVEKAR and S. K. KULKARNI JATKAR, Bangalore.

In a previous communication it was shown that the equilibrium conversion of an equimolecular mixture of ethyl alcohol and acetic acid was 75 per cent. at 230° using potash alum and silica gel as catalysts. This work has been continued in order to find the temperature coefficient of the equilibrium constant. With equal rates of flow, ferric alum, phosphoric acid, sodium hydrogen sulphate, potassium hydrogen sulphate, silica gel alone and with 10 per cent. zirconium oxide and activated carbon gave at 150°, 5, 75, 40, 80, 50, 38 and 75 per cent. conversions respectively. The conversion with potassium hydrogen sulphate as the catalyst did not increase with reduction of rate. The result was confirmed by approaching the equilibrium from both directions.

143. The influence of Ni-Th-Ce promoters on the catalytic activity of Fe-Cu catalyst, supported on asbestos (Fe : Cu :: 4 : 1) in the synthesis of petroleum hydrocarbons from water-gas at ordinary pressure.

J. C. GHOSH and SUKUMAR SEN, Dacca.

It was found that the Fe-Cu catalyst of Fischer could be improved by using Ni as promoter. The best results were obtained with a catalyst of the composition Fe-Cu-Ni (4 : 1 : 22) containing traces of Th and Ce (Ni : Th : Ce :: 8 : 95 : 13) when, at 250°C. at a rate of passage of 10 c.c. per minute over 10 c.c. of catalyst material, a conversion of 21% by weight of the reacting gases was obtained at a single passage without any deposition of C.

Experimental data for a continuous experiment extending over 14 hours are given below :—

Wt. of water-gas passed over catalyst 5.49 gms.	Wt. of hydrocarbon obtained 1.14 gms.	Heat of combustion of reaction products 23,500 cal.
Heat of combustion 16,100 cal.	Theoretical yield of hydrocarbon :—1.3 grams.	

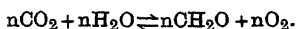
By following the reaction quantitatively it was found that there was always a periodic variation of the unsaturated-hydrocarbon-content of the effluent gases and under certain conditions of their other constituents as well.

144. Influence of temperature and light intensity on photosynthesis and respiration.

N. R. DHAR, Allahabad.

1. The Arrhenius relation connecting velocity and temperature of a reaction which is applicable to ordinary chemical reactions, is not valid in the case of the influence of temperature on photosynthesis in plants. The non-applicability of the Arrhenius relation to photosynthesis and many other phenomena in plant life can be explained from the following considerations :—

(a) It appears that in plant life, the following opposing reactions are taking place :—



The direct action (photosynthesis) is being opposed by the reverse reaction (respiration) which increases according to the law of mass action with increase in the concentration of carbohydrates formed from photosynthesis.

(b) There is reason to believe that the velocity of respiration in plants is appreciably accelerated by light.

(c) The influence of temperature on respiration appears to be greater than that on photosynthesis.

2. The greater influence of temperature on photosynthesis in presence of strong light than that in weak light can be explained from the foregoing considerations. Hence, it is needless to assume that there are two reactions involved in photosynthesis.

3. The observations of Willstätter and Stoll that leaves of low chlorophyll-content show a lower acceleration of photosynthesis with increase in temperature than the leaves of high chlorophyll-content have also been explained from the same point of view.

4. The experiments of Willstätter and Stoll showing that in chlorophyll-rich leaves an increase of light intensity does not affect photosynthesis have been explained from the view-point of 'exhaustion effect' as observed in ordinary photochemical reactions.

5. That oxygen is essential for photosynthesis appears to be due to the fact that plant life depends on oxygen respiration and the activity of the plant and along with it its photosynthetic power depend on its respiratory activity.

6. The photosynthetic activity is exceedingly high in young leaves and is not proportional to the chlorophyll-content. This is because the respiratory activity of young leaves is very high. In plant life, as well as in animal life, metabolism decreases with age.

7. In plant life in the absence of iron compounds, respiration and photosynthesis become defective as in chlorotic plants, because iron compounds accelerate respiration.

8. In the animal world, the length of life depends inversely as the rate of living. The duration of the catalytic activity of an active catalyst appears to be short. These considerations are applicable to plant life as well.

9. The phenomenon of 'solarisation', that is, the disappearance of carbohydrates formed from photosynthesis after prolonged illumination appears to be due to respiration, that is, their oxidation by oxygen in presence of light. The respiration, that is, the oxidation of carbohydrates is also increased by increase of temperature caused by light absorption.

10. The compensation point, that is, the light intensity at which the photosynthetic and respiratory activity of plants compensates each other, decreases with decrease of temperature.

11. Respiration appears to be the more fundamental reaction in plant and is more important to plant life than photosynthesis which predominates in plants only under restricted conditions of temperature and light intensity.

145. Formaldehyde in rain water.

N. R. DHAR and ATMA RAM, Allahabad.

1. It has been observed that freshly collected rain water contains formaldehyde to the extent of 0.001 to 0.00015 grams per litre.

2. The amount of formaldehyde in rain water increases if the rain is preceded by bright sunny days. When the days are cloudy and there are frequent showers, the amount of formaldehyde decreases and may be altogether absent immediately after a very heavy shower.

3. The rain water should be immediately analysed when collected, because a part of the formaldehyde is lost by vaporisation and another part by polymerisation.

4. It is believed that the formaldehyde in rain water is formed by the combination of carbon dioxide and water vapour present in the atmosphere by the absorption of ultra-violet light from the sun.

5. Formaldehyde in rain water cannot be due to the photo-decomposition of substances of vegetable origin.

6. Formaldehyde vapour shows a light absorption between 3700 and 2500 \AA , the maximum absorption being at 2935 \AA , characteristic of aldehydes. It appears that not only ozone absorbs radiations of short wavelengths from the sun, but the formaldehyde present in the atmosphere also absorbs solar ultra-violet radiations.

7. It appears that the water molecules are decomposed by absorption of short-wave radiations and the hydrogen atoms set free reduce carbon dioxide to formaldehyde, which may be formed in the atmosphere at heights less than those where ozone is generated.

146. Formation of periodic precipitates in the complete absence of gels.

N. R. DHAR and R. N. MITTRA, Allahabad.

In a recent note to *Nature*, it was reported that periodic precipitates are obtained in the coagulation of sols of ferric, chromic, and stannic hydroxides by electrolytes. The authors have now obtained similar periodic precipitates with sols of ceric, zirconium, thorium hydroxides and vanadic acid and ferric arsenate when coagulated by univalent electrolytes. For obtaining this periodicity, the sols must be fairly pure and the velocity of coagulation low. The authors have determined the adsorption of the hydroxide sols by their respective hydroxides in the precipitated condition, and have observed that when the sols are fairly pure they are markedly adsorbed by their precipitates. These results on Liesegang ring formation obtained in the complete absence of a gel or a foreign medium are due to the adsorption of the sols by their precipitates. Hence, in order to obtain Liesegang rings, it is necessary that the sol and its precipitate should co-exist for a sufficiently long time. All these results are easily explained from the theory of Liesegang ring formation advanced by Dhar and Chatterji in 1924.

147. Constitution of iodic acid and potassium iodate.

M. R. NAYAR and TOTA RAM GAIROLA, Lucknow.

From precipitation values of colloidal solutions by means of electrolytes Dhar and co-workers found that iodate ion probably was bivalent. (Dhar, *J. Ind. Chem. Soc.*, 1928, p. 591; *ibid.*, 1932, p. 322.) They have attempted to solve the problem by three methods :—

- (1) Ostwald's conductivity method.
- (2) Electrometric titration of HIO_3 with NaOH by means of an oxygen electrode.
- (3) Determination of Van't Hoff factor from freezing point depression of KIO_3 solution.

All the three methods give indications that iodates in solution contain only two ions and that iodic acid is probably mono-basic.

148. Studies on crystallisation and super-saturation.

M. R. NAYAR and L. N. SRIVASTAVA, Lucknow.

In continuation of the work reported before the *Academy of Sciences*, U.P. (*Proceedings*, Vol. I, Dec. 1931), the authors have determined the supersolubility curve for oxalic acid in water, and the curves for other substances are being obtained.

149. Study on the arsenic content of the sandalwood and oil derived from trees treated with arsenical solutions.

A. V. VARADARAJA IYENGAR, Bangalore.

It has been shown by the author elsewhere that a very strong solution of arsenic kills effectively diseased sandal plants. In view of the fact that the heartwood and oil from sandal trees are used in medicine and industry, it was desirable to know whether arsenic passed into the heartwood and also into the oil. For this purpose, the heartwood from treated trees was digested with a mixture of HNO_3 and H_2SO_4 in the proportion of 7 : 3 and after complete removal of nitrous fumes, the residue was tested for arsenic by the Gutzeit method. It was found that the heartwood contained arsenic as As_2O_3 to the extent of 0.00006% to 0.00002% and in a few cases no trace of arsenic could be detected.

The oil was extracted by the solvent method, digested and tested for arsenic by the method detailed above, with the result that no arsenic could be detected. The extraction has been carried out by the steam distillation method and the oil is being tested for its arsenic content.

150. Dilatometric studies in enzyme action. Part III.—Glucosides.

H. B. SREERANGACHAR and M. SREENIVASAYA, Bangalore.

A dilatometric study of the enzyme hydrolysis of three glucosides, amygdalin, arbutin, and salicin has been made by means of the dilatometer described before (*J. Indian Inst. Sci.*, 13 A, 1932).

The amount of reducing sugar liberated in a given period is proportional to the volume change occurring in the dilatometer. The contraction constant per grammolecule of the glucoside is calculated from the observed depression and the corresponding amount of glucoside hydrolysed.

Emulsin-salicin system gives a contraction constant of 4.10. In the case of emulsin-amygdalin and emulsin-arbutin however no volume change is observed during hydrolysis.

The significance of these results is discussed.

151. Dilatometric studies in enzyme action. Part IV.—Polysaccharides.

H. B. SREERANGACHAR and M. SREENIVASAYA, Bangalore.

The hydrolysis of the two colloidal polysaccharides, starch and glycogen, by four different diastases, pancreatin, ptyalin, malt diastase, and taka-diastase has been investigated in the dilatometer. The contraction constants of the reaction are calculated on 100 gms. of the substrate.

	Pancreatin.	Ptyalin.	Malt diastase.	Taka-diastase.
Starch ..	0.68	0.675	0.79	1.57
Glycogen ..	0.45	0.83	0.54	1.47

The constants tabulated above reveal that starch is hydrolysed by pancreatin and ptyalin to very nearly the same extent while malt and taka-diastases carry on the reaction to a further stage, the taka-diastase

bringing about the maximum hydrolysis. In the case of glycogen-hydrolysis also, pancreatin gives the least and taka-diastrase the highest depression.

In every case the reaction has been followed by an entirely independent chemical method involving the estimation of the reducing sugars released during the hydrolysis. It is therefore possible to correlate the total depression with the amount of sugar liberated and arrive at a constant which has a relation to a grammolecule of sugar.

152. Dilatometric studies in enzyme action. Part V.— Estimation of urea and arginine.

H. B. SREERANGACHAR and M. SREENIVASAYA, Bangalore.

Changes in volume which accompany enzyme reactions are proportional to the amount of substrate hydrolysed. The α contraction constants of enzyme-substrate systems which can be determined are useful in the estimation of substrates in physiological fluids. The contraction constants of urease-urea and arginase-arginine which have been found to be 24.13 and 5.02 respectively have been utilised for the estimation of urea in urine and arginine in gelatin and casein hydrolysates.

	Urea in 1 litre of urine.		Percentage of arginine in.	
	Urine No. 1.	Urine No. 2.	Gelatin.	Casein.
	gms.	gms.		
Dilatometric method ..	6.085	5.82	7.95	3.52
Chemical method ..	6.317	5.94	7.8	3.33

The results of dilatometric estimation as well as those by chemical methods of estimation are in fair agreement.

153. Dilatometric studies in enzyme action. Part VI.— Kinetics and contraction constants of Inulin-Inulase system.

N. KESHAVA IYENGAR and M. SREENIVASAYA, Bangalore.

The kinetics of inulase have been investigated in the dilatometer and also followed chemically by periodic estimations of the fructose produced during the reaction. The two sets of results reveal a definite proportionality of the dilatometric depressions with the amounts of sugar liberated. The contraction constant which has been calculated per 100 grams of the substrate is found to be 3.65. When expressed on the basis of a grammolecule of sugar produced, the contraction constant attains a value of 7.1.

154. Dilatometric studies in enzyme action. Part VII.— Hydrolysis of glycine anhydride.

M. SREENIVASAN and M. SREENIVASAYA, Bangalore.

The hydrolysis of glycine anhydride to the corresponding dipeptide and the dipeptide to two molecules of glycine has been followed in the

dilatometer. The first reaction involving the fission of the di-keto-piperazine ring, is brought about by dilute (N/10) alkali and is accompanied by a rise in the dilatometric column. The reaction reaches an equilibrium in about 10 to 12 hours, after which the reaction mixture is analysed for the free amino-nitrogen which gives a measure of the dipeptide produced. The observed dilatometric elevation is proportional to the amount of the anhydride hydrolysed and therefore the elevation constant per grammolecule of the anhydride can be calculated. In the case of di-keto-piperazine the elevation constant is found to be 7.6.

The hydrolysis of the dipeptide is being followed by enzymes in the dilatometer to determine the constant for the second stage of the reaction.

155. Studies in the resistance of sandal plants to spike disease. Part III.—Nitrogenous constituents.

Y. V. SREENIVASA RAO and M. SREENIVASAYA, Bangalore.

In a preceding communication (*Proceedings, Indian Science Congress, 1931, Section of Chemistry*) it was pointed out that leguminous hosts in general render the parasitic sandal plant particularly susceptible. The chemical factors which influence susceptibility and resistance to disease have now been investigated particularly with reference to the nitrogenous constituents, some of which appear to encourage the rapid multiplication and increase the virulence of the infective principle.

Susceptible sandal plants nourished by hosts like *Acaria farnesiana* are characterised by a high content of basic nitrogen while those fed by hosts like Margosa, *Rutea graveolens* contain a high percentage of the non-basic fraction.

Form of Nitrogen.	Results expressed on percentage total water soluble nitrogen.	
	Susceptible sandal.	Resistant sandal.
Basic ..	16.78	6.4
Non-basic ..	70.00	90.0

A detailed analysis of the nature of basic and non-basic fractions is in progress.

156. Contributions to the study of spike disease of sandal. Part IV.—Studies in the resistance of sandal to spike.

M. SRINIVASAN and M. SREENIVASAYA, Bangalore.

Among the various factors known to influence disease-resistance in plants, the hydrogen ion concentration and buffering capacity play an important rôle. These two factors have been investigated with sandal plants which have been cultured in pots under controlled conditions and in association with known host plants. The buffering capacity of the tissue fluids has been determined not only with reference to the addition of alkali but also to the addition of acids. The significance of determining the buffering capacity of tissue fluids to addition of acids is realised, if attention is called to the fact that with the onset of disease, acids accumulate in the plant and favour the growth of the infective principle.

The hydrogen ion concentration and buffering capacity of various tissues of the plant, leaf, root, bark, and wood have been separately determined with a view to locate the region of maximum and significant change with respect to the above two factors. In general, the tissue fluids of the spiked plant possess a higher buffering value with respect to either acid or alkali. This can be correlated with the increase in the amino-nitrogen occurring with the onset of disease. The maximum change in the buffering capacity is found to occur in the root. The results are given in the following table:—

			pH.	Volume of titre to shift pH by unity for 2 c.c. of sap.	
				Acetic acid N 10 c.c.	NaOH N/10 c.c.
Leaf	{ Healthy	..	5.4	3.0	0.6
	{ Spiked	5.0	6.0	0.7
Root	{ Healthy	..	5.9	0.4	0.1
	{ Spiked	5.3	3.0	0.3
Bark	{ Healthy	..	5.0	3.0	0.3
	{ Spiked	4.9	5.5	0.5
Wood	{ Healthy	..	5.8	0.8	0.3
	{ Spiked	5.2	2.0	0.3

157. Contributions to the study of spike disease of sandal.
Part V.—Respiratory activity of diseased and healthy
tissues and tissue fluids.

N. KESHAVA IYENGAR and M. SREENIVASAYA, Bangalore.

A respiration study of the healthy and diseased tissues and tissue fluids of sandal has been made employing the Barcroft differential respirometer with modifications introduced by Dixon and Elliot (*Biochem. J.*, 1930) for quick and efficient CO₂ absorption. Healthy tissues and tissue fluids produce twice as much carbon dioxide as that generated by corresponding diseased materials. This significant result accounts for the accumulation of the products of incomplete combustion—the organic acids. The respiratory activity of healthy and diseased leaves at different stages of growth and after treatment with liquid air, has been made.

158. On Inulase. Part II.—Methods of purification.

N. KESHAVA IYENGAR and M. SREENIVASAYA, Bangalore.

Inulase from *Aspergillus* cultured on an aqueous extract of artichoke, is associated with other carbohydases, more particularly with invertase which occurs in considerable quantity. 1 c.c. of the extract acting upon 5 c.c. of 0.5 per cent. sucrose produces 15.5 mgms. of reducing sugar (calculated as glucose). Purification of the inulase extract, therefore, amounted practically to an elimination of the accompanying invertase and the adsorption method recommended by Pringsheim was followed. Calcium hydrogen phosphate exhibits a preferential adsorption for inulase which could be eluted out by citrate buffer at 3.8 pH. Sorensen's phosphate buffer at 6.8 pH was, however, found to be a more efficient elutant. Repeated adsorptions and elutions increase the purity of inulase but

bring about a loss in the activity of the resulting extract either due to material losses of the enzyme or inactivation or both.

Aluminium and zirconium hydroxides were found to adsorb both the enzymes from the extracts quantitatively and this fact could be utilised for a preliminary purification to eliminate the inert solids associated with the extract.

Short period dialysis (48 hrs.) of the extract in parchment thimbles against a stream of distilled water shows that invertase passes out more quickly than inulase. Continued dialysis for 5 days results in complete passage of both the enzymes.

159. Chemical examination of the seeds of *Pongamia Glabra*.

M. C. TUMMIN KATTI, Bangalore.

During the course of the complete analysis of the seeds with a view to find out the nature of the active principle responsible for the curative properties of the *hongay* oil three crystalline compounds, in addition to *Karanjin*, have been isolated and their properties described. The active principle appears to be a viscous non-saponifiable resinous matter. Other constituents isolated from the seeds, are fatty acids, phytosterol, and a large amount of sucrose. Clinical trials of the non-saponifiable resinous matter on a number of cases of skin diseases have confirmed the therapeutic activity of the oil.

160. A preliminary study on the cultivation of *Datura Stramonium*.

M. C. TUMMIN KATTI, Bangalore.

In order to study the climatic effects on and the seasonal variations in the yield and the alkaloidal content of *D. stramonium* leaves, experiments with small plots (16 x 12 feet) have been conducted.

The results obtained so far indicate that removal of flower-buds, as they appear, not only increases the yield of leaves by more than 100 per cent., but also the alkaloidal content of the leaves from such plants increases by 30-40 per cent.

It is reported that sun-drying has a deleterious effect upon the quality of the drugs. The analysis of the leaves dried in the sun and in a hot air oven (40-50°C.) did not, however, indicate any difference in the alkaloidal content of the leaves.

161. Indian aconites.

M. C. TUMMIN KATTI, Bangalore.

In order to see if any of the varieties of aconites growing in Kashmir could be substituted for the official aconite, *Aconitum napellus*, two samples of aconites, *A. heterophyllum* and *A. chasmanthum*, have been analysed as to their alkaloidal content. *A. heterophyllum* has been found to contain a small amount (0.047 per cent.) while *A. chasmanthum* contained nearly 7.0 per cent. of ether-soluble alkaloids. The principle alkaloid (Indaconitine) from *A. chasmanthum* is not identical with aconite but has got very similar chemical and physiological properties.

The tincture of *A. chasmanthum* when fresh is found to be physiologically 13-14 times as active as a fresh tincture of *A. napellus*.

Just like the official tincture (Tincture, Aconite, B.P.), the tincture prepared from *A. chasmanthum* also deteriorates considerably in its physiological action on storage. The rate of deterioration with respect to time has been studied and the results described.

162. Chemical examination of the Rhizomes of *Rheum emodi*.

M. C. TUMMIN KATTI and GHOUSE MOHIYUDDIN, Bangalore.

During the course of the complete analysis of Indian Rhubarb, a number of compounds have been isolated. In addition to fatty acids and phytosterol, chrysophanic acid, frangula-emodin, rhein, a mixture of anthraquinone glucosides which on hydrolysis yielded chrysophanic acid and another glucoside-rhaponticin in considerable amounts have been isolated and identified.

163. Proteins of *Phaseolus mungo*.

H. JAI RAM, Bangalore.

The globulins from this legume have been obtained and fractionated into two distinct chemical entities differing from each other both in their content of nitrogen and sulphur. A very interesting feature is the existence in these globulins, of phosphorus which could not be eliminated in spite of repeated purification and evidence has also been obtained to show that it is in organic combination. The amount of phosphorus contained in any one of the fractions is constant for the particular globulin but the two differ very widely in their phosphorus contents. Further work is in progress to study the biological value of the individual proteins and the nature of the phosphorus linkage involved in the phosphoproteins.

164. The mechanism of synthesis of proteins in plants.

K. S. VARADACHAR, Bangalore.

In the previous years (*Proceedings of the Indian Science Congress, Section of Chemistry*, 1931 and 1932) experiments were reported on the injection of nitrogen-starved sunflower plants (*Helianthus annuus* Linn) with potassium nitrate solution and on studies of the changes undergone by the absorbed nitrate. In the present paper the author has studied sampling the injected plants every two hours, day and night, and analysing the samples for nitrogen distribution. The Hassmann numbers are discussed in their correlation to the synthesis of protein in plants. There is evidence to suggest that the high percentage of humin fraction observed (sometimes as high as 20 per cent. of the total N) is due to certain seasonal variations. Further experiments are in progress.

165. The pigment of the flowers of *Tagetes erecta*.

H. S. MAHAL and K. VENKATARAMAN, Lahore.

The yellow colouring matter of the flowers of *Tagetes erecta* (Hindi and Bengalee, Ganda; English, the French marigold) has been isolated and identified as the known quercetagetin, 3 : 5 : 6 : 7 : 3' : 4'-hexa-hydroxy-flavone.

166. Chemical investigation of Indian medicinal plants.

Part I.—Preliminary chemical examination of the root bark of *Capparis Horrida*.

S. N. CHAKRAVARTI and A. VENKATASUBBAN, Chidambaram, Madras.

A systematic analysis of the root bark, which is used as a cure for Cholera and as a sedative, stomachic, and anti-idriotic, has been made. The active principle of the root-bark is an alkaloid which has been isolated. The physiological and pharmacological action as well as the composition and the constitution of this alkaloid are under investigation.

167. Chemical investigation of Indian medicinal plants.
Part II.—Preliminary chemical examination of the leaves of *Pithecolobium Bigeminum*.

S. N. CHAKRAVARTI and KRISHNAMURTI GANAPATI,
Chidambaram, Madras.

A systematic analysis of the leaves of *Pithecolobium Bigeminum*, which is used as a cure for leprosy and also as a stimulant to promote the growth of hair, has been made, which shows that the active principle of the leaves is a mixture of acids, one of which is easily soluble in water but not in alcohol, whilst the other is readily soluble in alcohol but not in water. Alkaloids, glucosides, tannins, etc., were found absent.

168. Colouring constituents of alkanet root. Part II.—
Composition and derivatives of Anchusin.

D. N. MAJUMDAR and G. C. CHAKRAVARTI, Bangalore.

The ether extract of the root from which alkannin has been removed previously, gives about a 25 per cent. yield of the second colouring matter, anchusin. It gives a potassium and a barium compound of the formulæ $C_{30}H_{34}O_9K_2$ and $(C_{30}H_{34}O_9K)_2Ba$ respectively. The molecular weight of some simple derivatives also support the formula $C_{30}H_{36}O_9$ for anchusin.

A number of derivatives, $C_{30}H_{32}O_9(COCH_3)_4$; $C_{30}H_{31}O_9(COCH_3)_5$; $C_{30}H_{34}O_7(OCH_3)_2$; $C_{30}H_{32}O_7(OCH_3)_2(COCH_3)_2$; $C_{30}H_{32}O_9(CO \cdot C_6H_5)_4$; $C_{30}H_{32}O_9Br_4$ and $C_{30}H_{30}O_9Br_8$ have been obtained.

Oxidation with nitric acid gives different products which are some complex nitro-carboxylic acids together with simple acids like oxalic acid and succinic acid.

169. Colouring constituents of alkanet root. Part III.—
Isolation of a new colouring matter.

D. N. MAJUMDAR and G. C. CHAKRAVARTI, Bangalore.

The residue of the root after exhaustive extraction with ether gives a third colouring matter for which the name alkanninin is proposed. The method of its isolation and purification is described in detail. Some simple derivatives have been prepared for finding out its composition.

170. Isolation of β -naphthylamine, from coal tar.

S. K. GANGULY and P. C. GUHA, Bangalore.

Though a number of bases have been isolated from coal tar, no mention is made in the literature about the existence of β -naphthylamine. Anthracene oil (b.p. 270°–350°, Sp. Gr. at 25°, 1.0310) is extracted with hydrochloric acid, the acid extract, steam-distilled and the bases, precipitated with caustic soda, subjected to fractional distillation. The fraction coming over between 190°–245° at 30 mm. is treated with warm sulphuric acid (1 : 5) and on cooling the insoluble sulphate of the amino-base separates out as a solid which on being boiled with 10 per cent. caustic soda solution yields β -naphthylamine as white shining crystalline plates. After crystallisations from water it melts at 112°, yield 0.56 per cent. in this fraction. Identity has been confirmed by taking mixed melting point with a genuine sample and also from combustion results.

171. Examination of the Phenol and Cresol contents in the carbolic oil manufactured by Bengal Chemical and Pharmaceutical Works from Calcutta Gas Works tar.

S. K. GANGULY and P. C. GUHA, Bangalore.

The middle oil (b.p. 170° – 230° ; Sp. Gr. at 25° , 0.9876) contains tar acids to the extent of 30 per cent., bases 2.6 per cent., and neutral oils 67.4 per cent. The tar acids are repeatedly fractionated with fractionating columns under standard conditions, with necessary corrections of temperature due to variation of pressure. The phenol content found in the fraction up to 180° by 'Crystallisation point method'—5.7 per cent.; ortho-cresol (b.p. 187°)—11.98 per cent.; meta-cresol estimated as trinitro-compound (*Z. Angew. Chem.*, 1900, 13, 759)—2.17 per cent.; para-cresol and other higher acids of the series—10.15 per cent.

172. Chemical investigation of the high boiling bases of anthracene oil (B.p. 170° – 350°).

S. K. GANGULI and P. C. GUHA, Bangalore.

Excepting the isolation of some high boiling bases like di-methyl-quinolines and acridine in the high-boiling fractions of the bases obtained from coal-tar, no work appears to have been done on the isolation of the bases occurring in anthracene oil. The high-boiling bases show sign of decomposition when subjected to ordinary process of distillation. Their separation has been tried by fractional distillation under highly reduced pressure, viz. 2.3 mm. Fourteen fractions, each distilling within a range of five degrees from 85° – 155° , have been collected and their specific gravity, refractive index, and average composition studied to form an approximate idea about their composition.

Attempts for the isolation of individual carboxylic acids by oxidising the alkyl groups (*Ber.*, 1889, 22, 267) of the mixed bases have not been successful due to the fact that the mixture of acids is obtained only as a semi-solid viscous mass. Isolation of three individual solid esters melting respectively at 208° , 201° and 101° ($R\text{-COO}\cdot\text{CH}_2\text{-CO}\cdot\text{C}_6\text{H}_4\cdot\text{C}_6\text{H}_5$) has been effected.

173. On the problem of identity of jute and cotton celluloses.

J. K. CHOWDHURY and N. N. BOSE, Dacca.

The standard celluloses prepared from cotton and jute were subjected to different chemical treatments. The degree of acetylation and yield of the acetylated product, yield of methyl-glucoside and of crystalline glucose, yield of cellobiose-octacetate, yield and methoxyl content of methylated cellulose—all gave identical results with both the celluloses. The viscose reaction, surface tension of viscose solutions and viscosity of solutions of cellulose and its carefully prepared derivatives, however, indicated wide difference in the case of the two celluloses. It is suggested that both the celluloses consist of glucose units only, combined together in a similar manner. The number of glucose units is however different in the two cases—cotton cellulose consisting of a larger number of glucose units than jute cellulose.

174. On the preparation of pure cellulose from jute fibre.

J. K. CHOWDHURY and N. N. BOSE, Dacca.

Cotton cellulose prepared by the method of Correy and Grey without the use of bleaching agents and treated with 17.5% alkali in the cold was used as a standard for the comparison of purity. Jute fibre, delignified by chlorine peroxide method, was extracted with hot water and then

alternately treated with boiling 5% alkali and cold 17% caustic soda several times. In ash content, furfural value and solubility in 17% alkali, this jute cellulose was found to have identical values with the standard cotton cellulose. Lignin, urenic acid, fat, and resin were found absent in both the celluloses.

175. Jute-leaves—*Corchorus Capsularis*. Part I.—Their chemical composition.

N. K. SEN, Dacca.

The present investigation forms a systematic analysis of the various substances present in the jute-leaves. The leaves of *Corchorus Capsularis* were extracted successively with the following solvents :—

	Per cent. of extract.
Petroleum ether (b.p. 40°–50°)	9.80
Ethyl ether	2.01
Chloroform	1.73
Alcohol (95%)	12.26
Water	7.35
Residue	63.25
Loss	3.60
Total	100.00

The light petroleum extracted a vegetable wax and essential oil, ether, chlorophyll and a small quantity of a crystalline solid of phenolic character, the chloroform, a trace of bitter principle and the alcohol, most of the bitter principle and of tannin but no alkaloids, the water extracted reducing carbohydrates and inorganic salts mainly potassium chloride.

From the alcoholic extract of the jute-leaf a bitter substance was isolated as white amorphous powder which is identical with Capsularin isolated by Saha and Choudhury (*J. Chem. Soc.*, 1922, 121, 1044). It also bears a close relationship with Corchorin isolated from jute seeds by the author (*Indian Science Congress*, 1930). Further work on the constitution of the bitter principle is in progress.

176. Pectins and hemicelluloses from some of the Indian fruits and vegetables.

H. S. SHARMA, Bangalore.

Investigations on the pectin contents of some of the Indian fruits and vegetables reveal that some of them are excellent commercial sources for pectin, which is extensively used in the manufacture of jams and jellies. Pectin was isolated from palm-fruit, chow-chow, turnips, gourd, and papaya. Gourd and papaya especially contain at certain stages of maturation, as much as 35 per cent. and 27 per cent. respectively of pectin, and therefore can be profitably used as commercial sources. Some of these pectins when precipitated with acetone and ethyl alcohol, give fractions whose chemical nature is under investigation. The pectin from papaya when refluxed with dilute alkalis, changes into a product whose properties are very similar to those of the hemicellulose obtained directly from raw materials. Further evidence of the degradation of pectin to hemicelluloses is being obtained by similar treatment of pectin from other sources.

Investigations on the inter-relationship of sugars, pectins, hemicelluloses, celluloses, and lignins are in progress.

177. Physiological products of the lac insect. Part I.—The nitrogenous constituents of the body and fluid.

N. K. RANGA RAO and M. SREENIVASAYA, Bangalore.

Lac-encrustation containing mature insects, three weeks prior to swarming, after mechanical separation from the green twigs, was ground with 1.0 per cent. sodium chloride solution. The blood red extract was centrifuged to eliminate fat and suspended particles. The clean deep red extract, on acidification gave a nitrogen value of 12.1 per cent. The filtrate, on saturation with salt, yields a flocculent precipitate (B), which can be recovered by centrifuging. The clear centrifugate containing all the lower serum-proteoses and poly-peptides represents the third fraction which was also subjected to Van Slyke analysis. A detailed study of the bases has been carried out by Kossel's silver-baryta method. The basic fraction amounts to about 50 per cent. of the total nitrogen and 25 per cent. represents the histidine fraction. The analytical data strongly points to the existence of a histoprotamine closely allied in composition to the protamine-like body isolated by Dunn from the testicles of *Sardina Coerula*. Further fraction of the serum-proteoses of the blood is under progress.

178. Shellac esters. Part I.

M. VENUGOPALAN and N. NARASIMHA MURTY, Namkum.

Attempts are made for preparing some shellac esters of glycerine and ethylene glycol with a view to improve the properties and increase the use of shellac in the various industries. Optimum conditions for the esterification process with regard to time and temperature of reaction, and the action of various inorganic catalysts have been studied. The different shellac esters prepared have been examined for such specific properties as colour, appearance, acid value, solubility in different solvents, resistance to water, effect of baking, etc. The use of these esters as possible substitutes for plasticisers and also as a medium for preparing some adhesive compositions have been suggested.

Esterification with beta-naphthol, resorcinol, pyrogallol, etc., did not yield esters of any appreciable reduction in acid value. The products obtained from these are hard and brittle but are greenish dark in colour.

Experiments in connection with the preparation and study of the properties of some mixed esters of shellac in combination with other natural and synthetic resins such as rosin, copal, glytal, etc., are in progress. The use of these esters in the development of some oil-varnishes is also being studied.

179. Effect of plasticisers on shellac films.

M. RANGASWAMI, Namkum.

The effect of including a plasticiser in the composition of a shellac varnish on some of the properties of the resulting film has been investigated.

Working with pure unbleached shellac varnishes it has been found that no advantage will be gained by plasticising the film from the point of view of both the amount of water absorbed and the opacity of the film as a result of water absorption since plasticised films are as much affected by water as pure shellac films; plasticising will, nevertheless, improve the flexibility of the film to a certain extent as a result of which the film will much less readily crack when subjected to alternating conditions of extreme drought and humidity.

It has also been shown that the plasticisers will, to a small extent, increase the resistance of the film to scratching and abrasion but will not, however, prevent the films from cracking when subjected to the bending test.

180. Electro-deposition of shellac.

N. NARASIMHA MURTY, Namkum.

The colloid chemical aspects of alkaline solutions of shellac are discussed. The experimental portion on the electro-deposition deals with the nature of the deposits obtained from (i) seed lac, (ii) ether-insoluble lac, (iii) ether-soluble lac, (iv) shellac. The influence of chlorine ion is found to be the greatest and that of acetate ion the least in obtaining a polymerised deposit. The alcohol-soluble portion of the polymerised deposit consists of ether-soluble lac, while the alcohol-insoluble portion of the deposit consists of ether-insoluble lac. These results are in accord with the observations made by Harries and Nagel in studying the effect of hydrochloric acid on the polymerisation of ether-insoluble portion of shellac. The scope of further work in connection with electro-deposition is indicated.

181. Structure of *Psoralen*—one of the constituents of the seeds of *Psoralea Corylifolia* (Linn).

H. S. JOIS and B. L. MANJUNATH, Bangalore.

A small amount of solid material separated from the oil obtained by the extraction of the seeds of *Psoralea Corylifolia* with low boiling petroleum (yield 0.2 to 0.3 per cent. of the weight of the seeds). The substance was resolved into two constituents by repeated fractional crystallisations from various solvents. The main component, $C_{11}H_8O_3$, named *Psoralen* melted at 163° and the other at 113° . Both of them were found to be lactic bodies.

Psoralen can be crystallised from water in long colourless needles, and possesses a distinct aromatic odour. The alkaline solution is reduced by means of sodium amalgam and *di-hydro-psoralic acid* is precipitated on acidification. This acid when distilled *in vacuo* gives *di-hydro-psoralen*, $C_{11}H_8O_3$. *Psoralen*, when treated with methyl sulphate, gave the *methyl-ester of methoxy-psoralic acid* from which the free acid could be obtained by saponification.

Evidence is adduced to indicate that *Psoralen* may be regarded as belonging to the class of Cumarino-Cumarones and is the parent substance of the *Bergapten* group.

Further detailed studies are in progress.

182. The chemical examination of the roots of *Aristolochia Indica* (Linn). Part II.

B. L. MANJUNATH, S. SIDDAPPA, and S. VENKATA RAO, Bangalore.

The alcoholic extract of 75 Kg. of the roots was first subjected to steam distillation for obtaining the essential oil, the characteristics of which have been reported in a previous communication (*Proceedings, Indian Science Congress*, 1932).

This essential oil consisted principally of a sesquiterpene (b.p. $121^\circ/10$ mm.), and a sesquiterpene alcohol (b.p. $158^\circ/10$ mm.). A considerable quantity of a resin insoluble in alcohol separated after steam distillation. The aqueous layer on treatment with sodium carbonate gave a small amount of alkaloidal material. This was extracted with chloroform and the principal component was found to have the composition $C_{24}H_{25}O_4N$ and melted at 158.9° with decomposition. The hydrochloride

decomposed at 266°. In addition to this a small amount of the hydrochloride of an alkaloid melting at 310° (0.3 g.) has been isolated. The free base from this was found to be difficultly soluble in most of the organic solvents.

The residue left after steam distillation was dissolved in alcohol and separated from resinous material, dried on the powdered roots and extracted successively with petroleum ether, ether, chloroform, ethyl acetate, and alcohol.

The petroleum extract gave 1.5 Kg. of a dark brown oil, from which a small amount of phytosterol glucoside separated out gradually. A detailed examination of the constituents of the oil is included in the paper. It is of interest to note that the unsaponifiable matter contained a large proportion of the sesquiterpene alcohol already referred to, and also a phytosterol melting at 137°.

A yellow crystalline bitter principle (m.p. 276°) was isolated from the ether extract. The rest consisted mainly of resinous bodies. The ether extract also contained small amounts of basic material. A considerable proportion of the alkaloid occurring in the free state in the plant was obtained from the chloroform extract. The bitter principle was also recovered from the chloroform and ethyl acetate extracts. Further indications were obtained of the presence of glucosidic constituents mainly of the bitter principle in ethyl acetate and alcohol fractions. Further work is in progress.

183. Proteins of Fenugreek.

Y. V. SREENIVASA RAO and M. SREENIVASAYA, Bangalore.

With a 6 per cent. sodium chloride solution, 40 per cent. of the total nitrogen present in the Fenugreek powder can be extracted. On dialysis in fluted filters of parchment against a slow stream of distilled water for five days the salt extract gave a precipitate (A) the globulin, which can conveniently be recovered by centrifuging. On acidification the clear centrifugate yields a flocculent precipitate (B) which represents the albumin fraction of Fenugreek. A and B on analysis gave respectively the following percentages: Total nitrogen 17.2 and 15.9, Phosphorus 0.00 and 0.31, and Sulphur 0.14 and 0.29. The Van Slyke analysis of the two preparations A and B reveals that the globulin is characterised by a surprisingly high content of histidine which is about four and a half times the average amount contained in other globulins compared. The albumin (B) constitutes an interesting protein containing both P and S in the molecule. A determination of the biological value of these fractions is contemplated.

184. The mucilage of Fenugreek (*Trigonella Foenum Greacum*).

B. N. SASTRI and C. R. HARIHARA IYER, Bangalore.

The mucilage isolated from the seeds, has been found to be a mannogalactan containing the two sugars in equal quantities. As usually prepared, it is associated with a nitrogenous impurity containing phosphorus, which could be precipitated by saturating the aqueous solution with magnesium or ammonium sulphate. A purified preparation, free from phosphorus and nitrogen, has been obtained thus showing that the mucilage is only a mannogalactan and not a silicophosphoric ester of mannogalactan as indicated by previous work.

185. A new constant for oils and fats.

K. J. BOSE and M. GOSWAMI, Calcutta.

With oils and fats containing unsaturated linkages the hypochlorous acid gives only addition products and no substitution occurs as in the case of iodine value determination.

The determination of hypochlorous acid value affords another additional advantage in the fact that this involves the simultaneous determination of saponification value.

186. The linolic acid content of milk-fats. Part I.—The butter-fat of the cow.

P. RAMASWAMI AYYAR and J. D. VASAVADA, Bangalore.

A sample of cow's ghee made from the milk of a Bangalore cow had a saponification value of 229.8 and an iodine value of 43.4. Oxidation of 15 grams of the saponified fat yielded after purification about 0.9 gram of a tetrahydroxystearic acid melting at 148–150°C., corresponding to about 5 per cent. of linolic acid on the fat as such.

Similar work on buffalo's ghee and other milk-fats is in progress. The significance of linolic acid content in relation to the latest researches on fat metabolism in animal bodies is discussed.

187. The fat from the seeds of *Garcinia Gambogia*.

P. RAMASWAMI AYYAR and J. D. VASAVADA, Bangalore.

The seeds kindly supplied by the Chief Conservator of Forests, Travancore, consisted of 46.7 per cent. of kernels and 53.3 per cent. of shells.

The former yielded to petroleum ether 37.6 per cent. of a pinkish white fat which had the following analytical constants:—

Solidification point	= 29.3°C.
Specific gravity	= 0.8948.
Iodine value	= 44.2.
Saponification value	= 184.3.
Unsaponifiable matter	= 1.2 per cent.

The detailed composition of its fatty acids is under investigation.

188. Investigation of the component fatty acids and glycerides of *Mowha* and *Garcinia Morella* (Tamal) fats.

D. R. DHINGRA and G. L. SETH, Lahore.

The component fatty acids and glycerides of the two fats have been determined fully and it has been found that they consist mainly of palmitic, stearic, and oleic acids, with small amounts of myristic and linoleic acids. They are good sources of stearine which can be profitably extracted on a commercial basis.

189. Studies of the component fatty acids and glycerides of some uncommon milk fats.

D. R. DHINGRA, Lahore.

The composition of the fatty acids and glycerides of goat's milk and sheep milk fats has been investigated fully and their relationship with the ordinary butter fats established.

190. Studies in fish oils—chemical analysis of the body oils of Rohita, Mirgal and Dhain fish (fresh-water fish from Bengal).

N. C. DATTA and B. N. BANERJEE, Bangalore.

A detailed examination of the different constituent and the composition of complex mixtures of fatty acids present in the fish oils has

been done. These body oils contain highly unsaturated acid of C_{18} , C_{20} , and C_{24} series like the cod-liver oils.

Compared to the unsaturated acids in the liver oil of Rohita investigated by J. K. Choudhury and Pulin Behari Sarcar (*Journal, Indian Chemical Society*, 1930, Vol. VII, 309).

Liver Oil.			Body Oil.		
Solid acid	..	28.1%	Solid acid	..	28.7%
Liquid acid	..	71.9%	Liquid acid	..	71.3%
Mixed fatty acid I.V.		149.6	Mixed fatty acid I.V.		130.2
Mean mol. wt.	..	295.3	Mean mol. wt.	..	290.0
I.V. of liquid acid	..	180.9	I.V. of liquid acid	..	161.5

The body oil of Rohita was found to contain the same unsaturated acid as liver oils—the only difference being that the percentage of Hexadecatrienoic acid and Linolenic acid in the body oil is slightly lower. There is no Asellinic acid in the body oil: there is a small percentage of Linolic acid in the body oil which is absent from the liver oil.

191. Cashew shell oil. Part II.

Y. K. RAGHUNATHA RAO, Bangalore.

In continuation of communication (*Proceedings, Indian Science Congress*, 1931, *Section of Chemistry*), country-rendered shell oil from *Anacardium Occidentale* has been analysed. The oil has Sp. Gr. $30(1.01)$, acid value (64.2), saponification value (101.5), iodine value (328).

Acids (45–55 per cent.), chiefly anacardic acid ($C_{22}H_{32}O_3$), have iodine value (331), give a violet colour with ferric chloride, give equivalent and molecular weight in benzene (340).

Phenols (35–45 per cent.) have iodine value (305), colour pink with ferric chloride and consist chiefly of cardol. Combustion of the purified liquid and molecular weight in benzene (308) support the formula $C_{21}H_{30}O_2$. It is being further studied.

192. Oil-soluble vitamin A in some pulses and fishes of Bengal.

H. N. BANERJEE and N. C. NAG, Calcutta.

In continuation of the work in connection with the chemical examination of some pulses and their oils (*Proceedings, Indian Science Congress*, XVI and XIX; *Trans. Bose Institute*, Vol. VI and Vol. VII) further progress has been made. Vitamin A has been detected by $SbCl_3$ test in some of the oils extracted from the pulses, the vitamin being most pronounced in the unsaponifiable portion. It has been possible to take a few absorption band spectrographs of the $SbCl_3$ blue compound. Oils from some fishes, such as Rohit, Catla, and Ilisha, have also been found to give positive reaction. Comparison has been made with Cod-liver Oil. The reaction given by oils from *Cicer arietinum* (chhola) and Ilisha is most pronounced. As regards keeping quality, oil from *Cicer arietinum* has been found to give the vitamin test for months, while Ilisha Oil has been found to give the reaction for two to three weeks. Keeping quality and methods of extraction are still under observation. Tinctometric tests are in progress.

193. Artificial lubricating oil from oleic acid.

J. K. CHOWDHURY and A. C. CHAKRAVARTY, Dacca.

A viscous oily product has been obtained by polymerisation of oleic acid at 100°C. in an inert atmosphere with stannic chloride as catalyst. Mechanical stirring has been found to favour the reaction. With the progress of polymerisation, density, refractive index, and viscosity increased while the iodine value decreased. The maximum viscosity obtained was 285.1 EI at 26.5°C. and the minimum iodine value 19.48, the corresponding figures for oleic acid being 34.63 and 79 respectively.

The viscous product was decarboxylated by treatment with zinc dust at 360° for 2½ hours. The acid value fell from 178.6 to 12 by this treatment and hence the product was mainly a hydrocarbon in composition. The oil thus obtained, was highly viscous and was similar to unrefined petroleum lubricants in colour and smell, and, like petroleum products, exhibit fluorescence to a remarkable degree.

194. The effect of some electrolytes on the permeability of the intestinal membrane towards sugars.

K. C. SEN, Muktesar.

The object of this paper is to consider the mechanism of intestinal absorption of sugars from the point of view of colloidal-chemical theories, and to find out how far the facts arrived at experimentally can be explained by such theories. It is shown that certain ions definitely affect the permeability of the gut wall, and the calcium ion has apparently a specific effect on both *in vitro* and *in vivo* experiments, a fact which is not easily explained by the ordinary physico-chemical theories. The results are discussed in relation to the colloidal properties of the intestinal membrane.

195. Investigation on the proteolytic enzymes and their activators in *Calotropis Gigantia* (Akanda).

K. P. BASU and M. C. NATH, Dacca.

A proteolytic enzyme somewhat similar to papain has been found in the milky juice of Akanda. It hydrolyses gelatine, egg-albumin, casein, and fibrin, the optimum pH being 5 which is also the pH of the milky juice itself and the optimum temperature, 50°C. The enzyme is activated by potassium cyanide, sulphuretted hydrogen, and cystein but not by cystin. Peptone is not attacked even in the presence of activators and hydrolysis of the complex proteins proceeds only to the stage of peptone. Pyrophosphate retards hydrolysis but not in the presence of sulphuretted hydrogen or cyanide. Activation is probably brought about by a sulphur compound in SH but not in S-S form. A white crystalline sulphhydril compound of melting point, 98°C., has been isolated from the juice and this is probably the activator.

Further work is in progress.

196. Utilisation of waste molasses. Part I.—The preparation of smoking tobacco.

M. Q. DOJA and M. HUSSAIN, Patna.

In view of the increasing importance of the sugar industry in India an attempt has been made to solve the problem of the utilisation of waste molasses, by using them in the preparation of smoking tobacco manufactured by crude indigenous methods. We have tried to investigate the preparation of smoking tobacco in a strictly scientific manner. The tobacco leaves have been powdered in a disintegrator and the mixing of

the powdered tobacco and molasses has been carried out in roller mills. Variations have been tried with regard to the relative proportion of molasses and tobacco and the temperature of mixing the two substances. The nicotine content of the tobacco leaves and the quality of the product obtained in each case have been investigated. The 'lasting power' of the finished product has been determined by means of a specially designed apparatus.

197. Utilisation of Avaram (*Cassia auriculata*) bark.

K. A. N. RAO and S. L. JANNIAH, Bangalore.

Extracts containing 40 per cent. tannin have been prepared from Avaram bark and large-scale tanning experiments are being conducted with it. The paper also contains numerous data with regard to the day-to-day variation of tannin and precipitate of the vat-liquors during the course of bark-tanning.

198. Treatment of wood with creosote-water emulsions.

C. VARADHAN and K. ASWATHNARAIN RAO, Bangalore.

Stable emulsions of wood tar and coal tar creosotes with water (1 : 1) have been successfully used for pressure treatment of timber, both in the laboratory and in semi-commercial plant. Absorption data for a number of woods have been obtained.

199. Nutritive value of hill pasture. Part I.—The mineral-content of some pastures in relation to rainfall and drought.

A. C. ROY and K. C. SEN, Muktesar.

In the course of some nutritional experiments, it was necessary to estimate the lime and phosphoric acid content of some local pastures ordinarily used for the feeding of cattle, and in some winter-cut hay, a surprisingly low amount of phosphoric acid was found. An elaborate experiment was therefore planned to study the effect of environment on the mineral content of pastures from three specially chosen fields, and in this paper an account is given of the monthly variation of some mineral constituents and a correlation is made between the rainfall or drought and availability of the minerals for the growing pastures. The importance of this seasonal variation from the point of view of animal nutrition is also discussed.

200. Studies in the nutritive value of Indian vegetable food-stuffs. Part V.—The nutritive value of *Eleusine coracana*.

S. P. NIYOGI, N. NARAYANA, and B. G. DESAI, Bombay.

Eleusine coracana (Ragi or Nagli) is a staple millet of the Mysore State and contains 6–9 per cent. of protein. Consecutive treatment of the flo with dilute salt solution, cold 70 per cent. alcohol and subsequent boiling remove 70 per cent. of the total nitrogen. The residual nitrogen can be extracted even by prolonged treatment with dilute alkali. The protein soluble in cold alcohol was isolated and analysed. The protein contained both sulphur and phosphorus and was characterised by a very low iodine content. The basic amino-acids and a high tryptophane-content (330%) were found. Feeding experiments on albino rats were conducted at a 5% level of protein intake. The average digestibility and biological value of the total proteins of this millet were found to be 77.5 and 90.5 respectively.

201. Action of *B. coli* on conjugated bile acids.

K. P. BASU and S. C. CHAKRAVARTY, Dacca.

The object was to investigate if in the bile cycle the intestinal bacteria bring about a cleavage of the CO-NH linkage of the conjugated bile acids. A physiological sodium chloride suspension of *B. coli*, which had been previously cultured three times in bile salt medium, was employed. The action was tried on glycocholic and taurocholic acids at 37°C., at different pH using phosphate buffers. Using Willstätter's method of estimation of amino-acids no cleavage could be detected either in acid, neutral or alkaline medium.

202. The electronic mechanism of elimination of radicals from sulphonium hydroxides.

C. K. INGOLD and K. I. KURIYAN.

Sulphonium hydroxides may decompose in two possible directions; one giving an olefine and the other an alcohol. It was found that the relative ease of elimination of radicals as olefines is a measure of the relative electron-affinity of radicals. The order of the ease of elimination of radicals is

ISO-PROPYL > ETHYL > N-PROPYL > N-BUTYL > ISO-BUTYL.

203. Grouping of electrons and stability of sulphonium compounds.

C. K. INGOLD and K. I. KURIYAN.

There is evidence to show that a sextuple grouping of electrons confers stability to a compound. Jessop and Ingold (*J.C.S.*, 1930, 713) isolated Di-methyl sulphonium 9 fluorenylide. It is very unstable. The present workers stabilised the 9 carbon atom by di-nitrating the fluorenyl group, i.e. prepared Di-methyl di-nitro sulphonium fluorenylide. The importance of the preparation lies in the fact that a compound containing a carbon atom with a 'lone pair' of electrons has been isolated.

204. Studies in the ligno-cellulose group. Part III.

P. K. DAS and H. K. SEN, Calcutta.

The question whether lignin is chemically combined with cellulose in ligno-cellulose has been attempted to be decided by noticing the degree of acetylation—

(1) of sawdust on treatment with acetic acid, acetic anhydride mixture under 5 atmosphere pressure and corresponding steam heat;

(2) of cellulose isolated from sawdust by Schmidt's chlorine-peroxide process;

(3) of cellulose separated from sawdust by Cross and Bevan's process.

In all cases when the lignin is removed, the maximum acetyl value corresponding to diacetyl is obtained. Even on examining the acetic acid value after a few hours of acetylation an increased acetic acid value is noticed both in the case of chlorine-peroxide cellulose and Cross and Bevan cellulose. This would lend support to the view formerly expressed by the authors that lignin is chemically combined with cellulose in ligno-cellulose, for the most part at any rate.

1932, 19
in the ortho-crystallised

Adsorption of alkali by cotton and modified celluloses.
TARAPADA BHOWMIK and H. K. SEN, Calcutta.

Adsorption figures at various concentrations of alkali have been obtained, from which no evidence can be established that a real chemical

or additive combination between the alkali and the cellulose takes place. In some cases, however, molecular or multimolecular proportions of alkali are adsorbed, but the variations of such ratios with different concentrations of alkalis are so great that no conclusion can be drawn, contrary to views put forward by a few workers in this line.

206. Explosion of oxy-hydrogen mixtures.

H. N. CHATTERJEE, A. N. MITRA, and H. K. SEN, Calcutta.

While measuring the explosion temperatures of oxy-hydrogen mixtures in the presence of heated platinum wires, it was found that the catalytic effect of the different specimens of wires used was great on the temperatures of ignition. In order to investigate into this catalytic influence more thoroughly, we exploded oxy-hydrogen mixtures enclosed in soap-bubbles over electrically heated platinum wires of different catalytic conditions. On exploding these mixtures over plain, roughened, and platinised platinum, it was found that the ignition points with roughened wires were lower than those with plain wires and the temperature of ignition over platinised platinum was the least. We obtained similar results by igniting the gas mixtures in glass bulbs in which platinum wires were stretched axially, the temperature being measured in this case by observing the change in the electrical resistance of the wires.

Experiments on the order of reaction between oxygen and hydrogen when they combine in a heterogeneous way in presence of a heated platinum wire are now in progress. They point primarily to a bimolecular nature of the reaction.

207. A high pressure electrolytic cell.

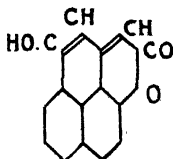
S. S. GHOSH and H. K. SEN, Calcutta.

The introduction of a *positive* compensator and of a liquid manometer in the circuit has decidedly improved the working facility of the cell already described in the *Journal of the Institute of Chemical Engineers*, London (1932). This *positive* compensator allows of the variation in volume of either the oxygen or the hydrogen compartment with such an exactness that the ratio 2 : 1 between the hydrogen and the oxygen compartments can be easily maintained. Data relating to power consumption have been experimentally determined. A parallel combination of three cells works at 1.55–1.63 volts. The electrical energy required for producing 1,000 c.ft. of hydrogen at 120 atmospheres is 112 K.W.H. Taking energy at $\frac{1}{4}$ d. per K.W.H., the cost of electrical energy for producing 1,000 c.ft. of H_2 and 500 c.ft. of O_2 is 2 shillings and 4 pence. The gases are 99.9% pure.

208. Some peri-peri-naphthindenofuran derivatives.

B. B. DEY and (MISS) K. RADHABAI, Madras.

A closer investigation of the properties of 5-hydroxy-2-keto-peri-peri-naphthindenofuran (Dey, *J.C.S.*, 1915, 1631) of the following formula,



has now been made. The melting point of the substance, purified by several crystallisations from pyridine, is found to be much higher than that previously reported (280°). The enolic hydroxyl

be so markedly acidic that it dissolves even in cold sodium carbonate, and the molecule can be esterified like a carboxylic acid by alcohols in the usual manner. The methyl (m.p. 236°), ethyl (m.p. 226°), and propyl (m.p. 196°) ethers have now been prepared by refluxing with the corresponding alcohol and sulphuric acid. These alkyl derivatives, however, are not to be regarded as esters, for they cannot be hydrolysed by boiling with 4N-caustic soda, while the corresponding acetyl derivative (m.p. 215°) is readily de-acetylated under these conditions.

The 3-chloro- and 3-bromo-, 5-hydroxy-2-keto-*peri-peri*-naphthindenofurans have also been synthesised. On halogenating β -naphthapyrone-4, acetic acid under the usual conditions, the halogen seems to enter position 3 exclusively and not to attack the reactive methylene H-atoms. The 3-chloro-acid forms hard tetragonal prisms (m.p. 154°) and decomposes above its melting temperature into 3-chloro-4-methyl- β -naphthapyrone (m.p. 136°), while the bromo acid forms soft needles (m.p. 190°) and passes into 3-bromo-4-methyl- β -naphthapyrone (m.p. 149°). They are converted almost quantitatively into the 3-chloro- and the 3-bromo-naphthindenofurans which crystallise from pyridine in orange-yellow needles not melting up to 350° , and yield acetyl derivatives crystallising in orange prisms melting at 230° and 214° respectively. The alcoholic solutions of all these derivatives show an intense green fluorescence.

209. *Cis*- and *Trans*-acids from 4-methyl- β -naphthapyrone.

B. B. DEY and A. K. LAKSHMINARAYANAN, Madras.

In addition to the *cis*-acid (m.p. 146°) reported previously (Dey, *J.C.S.*, 1915, 1630), an acid (m.p. 110°) which is apparently the *trans*-isomer has now been prepared by boiling the alkaline solution of the pyrone with mercuric oxide. The behaviour of the two acids on heating to their melting points—both pass into the pyrone with evolution of steam—and on crystallising from boiling solvents like alcohol, acetic acid etc., is so similar that the allocation of configurations on the usual grounds of stability is not possible here. Exposure of a dry chloroform solution of the two acids to ultra-violet rays for the same period has, however, revealed a difference: while the *trans*-acid (m.p. 110°) is slowly changed into the pyrone (m.p. 178°), the *cis*-acid (m.p. 146°) seems not to be affected at all.

The 3-chloro- and the 3-bromo-4-methyl- β -naphthapyrone also show a curious difference, though only of a quantitative character, when boiled with alkali. It had been reported (Dey, *loc. cit.*), that 3-chloro-4-methyl- β -naphthapyrone was distinguished from all other 3-halogenated coumarins by not yielding the expected furan derivative, but instead, a remarkably stable chloro-coumarinic acid. The observation has now been made that although chloro-coumarinic acid is the sole product obtained under the conditions employed previously, prolonged treatment with boiling strong potash converts a portion into the hitherto unknown β -naphtha-furan-carboxylic acid (m.p. 240°).

The 3-bromo-pyrone, on the other hand, rapidly changes on boiling with dilute aqueous alkali into the furan derivative only, no bromo-coumarinic acid being isolated in this case.

9. Coumarin-8-carboxylic acid.

B. B. DEY and Y. SANKARANARAYANAN, Madras.

This compound does not appear to have been described in literature. It has now been synthesised from 3-aldehydo-salicylic acid prepared from salicylic acid by the method of Duff and Bills (*J.C.S.*, 1907, 187) with a view to study the influence of the carboxyl-group on the stability of the *cis*- or coumarinic acid. It is obtained from hot water in shining needles (m.p. 242°).

211. Measurement of E.M.F. of the system : $H_2(Pt.) HCl. (c).$
Hgl. Hg. with hydrochloric acid solution below 0.01 N.
concentration.

K. KUMAR, Calcutta.

In presence of dissolved oxygen in hydrochloric acid solution pure mercury reacts with hydrochloric acid forming calomel and solutions below 0.01 N. appreciable decrease of hydrochloric acid concentration is produced. An exact e.m.f. measurement, therefore, is not possible. When, however, dissolved oxygen is removed by saturating hydrochloric acid solution with pure nitrogen, no change in concentration of the acid solution takes place and reproducible e.m.f. measurements are possible even in very dilute solutions.

212. Condensation of ethylene chlorhydrin with p- and o-nitro-phenols.

MISS B. N. KATRAK, Bombay.

With a view to prepare compounds which might possess antipyretic properties, ethylene chlorhydrin has been condensed with p- and o-nitro-phenol in presence of dilute alcohol, the corresponding nitro-ethers being formed. P-acetyl-amino-phenol has also been similarly condensed. Several derivatives of these compounds have also been obtained.

213. The condensation of ethylene chlorhydrin with naphthols and a study of the products obtained.

B. M. KAPADIA, Bombay.

Naphthols have been condensed with chlorohydrins.

α and β -naphthols on condensation with ethylene chlorohydrin yield β -hydroxyethyl- α -naphthyl ether and β -hydroxyethyl- β -naphthyl ether respectively. Acetyl and benzoyl derivatives have been prepared. Further work is in progress.

214. Condensation of ethylene chlorhydrin with resorcinol and derivatives of the products.

D. C. MOTWAIN and T. S. WHEELER, Bombay.

With a view to preparing substances of therapeutic value resorcinol, mono-methyl ether of resorcinol, resacetophenone, and ethyl resorcinol have been condensed with ethylene chlorhydrin. The method of condensing consists in dissolving the substance in 40% KOH and then refluxing the solution with the required quantity of ethylene chlorhydrin.

Resorcinol gives two products, the *mono* and the di- β -hydroxy ethyl ethers, of which the former has been prepared for the first time. The *diacetyl* derivative and the *dibenzoyl* derivative have also been prepared. The *monochloro* derivative $HO. CH_2. CH_2O. C_6H_4. Cl$ gives no coloration with $FeCl_3$. The *dichloro* derivative is a liquid and hydrolyses slowly to the stable mono-derivative.

The di- β -hydroxy ethyl ether of resorcinol has m.p. 95-96°C. Rindfusz and others (*J.A.C.S.*, 1920, 42, 157) obtained m.p. 81°C., because they did not separate it from the mono ether. The *diacetyl*, *dibenzoyl*, and *dichloro* derivative have been obtained.

Resacetophenone and ethylene chlorhydrin give a *mono ether* in which the OH group in o-position to the $COCH_3$ group cannot be replaced. The ether and its *mono acetyl* as well as *mono benzoyl* derivatives give violet coloration with $FeCl_3$. Its *phenylhydrazone* and *oxime* have been obtained. The p- β -hydroxy ethyl ether of o-hydroxy-acetophenone con-

denses, in alcoholic solutions, with benzaldehyde in presence of KOH to give the corresponding *chalkone*. The reactions of this *chalkone* will be used to confirm the position of the free nuclear hydroxyl group by the synthesis of the corresponding flavone.

M-methoxy phenol and ethylene chlorhydrin yield the corresponding *hydroxy ether*.

Ethyl resorcinol, prepared from Resacetophenone, with ethylene chlorhydrin yields (1) the *hydroxy ethyl ether*. With FeCl_3 it gives a violet coloration in alcoholic solution.

Further work is in progress.

215. Studies in the halogenation of toluene and its derivatives.

E. PAIS and T. S. WHEELER, Bombay.

I. (a) At present benzo tri-chloride, benzal bromide, and benzyl iodide represent the maximum substitution capacity for halogen (Cl, Br, I) of the toluene side-chain. The subject has now been studied in detail and the following new compounds have been obtained:—(1) *benzal chloro bromide*; (2) *benzo di-chloro bromide*; (3) *benzo chloro di-bromide*. It has been found that molecular bromine can displace chlorine from the side-chain under suitable conditions.

In this connection the exhaustive bromination of toluene in absence of a carrier has been examined and the following have been isolated for the first time:—(4) benzal bromide; (5) stilbene; (6) α and β di-bromo-stilbene; and (7) *di-phenyl tetra-bromo ethane*.

To isolate these compounds which can be distilled only under very low pressures and which boil close together a technique for control of fractions by density determination has been evolved.

(b) The compounds numbered 1, 2, 3, 4, as well as benzo tri-chloride and benzyl iodide have been brominated in presence of a catalyst and the following substituted derivatives have been obtained. These have been orientated by conversion to the corresponding bromo-benzoic acid; from benzal chloro bromide *o, p, bromo benzal chloro bromide*, and *o-p, di-bromo benzal chloro bromide*; from benzal bromide *o, m, p bromo benzal bromide*; from benzo di-chloro bromide, *m bromo benzo-di-chloro bromide*, *m-p di-bromo benzo di-chloro bromide*, and *m-p-m, tri-bromo benzo di-chloro bromide*; from benzo-chloro di-bromide—*m-bromo benzo chloro di-bromide*, *m-p di-bromo benzo chloro di-bromide*, and *m-p-m tri-bromo benzo chloro di-bromide*; from benzo-trichloride—*m bromo benzo tri-chloride*, *o-m, and m-p, di-bromo benzo tri-chloride* and *m-p-m tri-bromo-benzo tri-chloride*; from benzyl iodide *p-bromo benzyl iodide*, *o-p di-bromo benzyl iodide*, and *o-p-o tri-bromo benzyl iodide*.

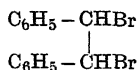
(c) Benzyl bromide and benzal bromide have been chlorinated in the absence of a catalyser, both in the dark and in the light. It is found that light plays an active part in the chlorination of these compounds at various temperatures. The following have been obtained on chlorination in the dark:—from benzyl bromide, benzo trichloride, *benzal chloro bromide*, *m-chloro benzo di-chloro bromide*, *m-p, di-chloro benzo di-chloro bromide*, and symmetrical *di-p-chloro phenyl di-chloro di-bromo ethane*; from benzal bromide, benzo-tri-chloride, *benzal chloro bromide*, *p-chloro benzal chloro bromide*, *m-p di-chloro benzo di-chloro bromide*, and *o-p, di-chloro benzal chloro bromide*.

Benzyl bromide and benzal bromide chlorinated in the light at 30°C. and 110°C. yielded only benzo tri-chloride.

(d) Experiments have been made on the action of potassium iodide and sodium iodide on benzal chloride, benzo tri-chloride, and benzal bromide, with and without solvent. The reaction is vigorous in the former case and iodine vapours are evolved.

Compound containing an atom of iodine and any other halogen

in the side-chain are quite unstable. Benzal chloride and potassium iodide gives tarry matter and stilbene; while benzal bromide and potassium iodide yields α di-bromo stilbene



Benzal bromide is highly reactive. Thus with pyridine in presence of copper powder it gives presumably *phenyl di-pyridyl methane*. This type of condensation with pyridine appears to be new.

II. Molecular weight determinations of the compounds by a modification of the camphor method have been made.

III. The density of the new liquid halogen compounds has been accurately determined to fix the molecular volume of halogen in the side-chain of aromatic compounds.

216. A study of the production of camphor.

B. G. S. ACHARYA and T. S. WHEELER, Bombay.

The production of camphor from pinene is being systematically studied, with a view to improving the yield and to replacing expensive by cheap chemicals. The work on the first step, the production of pinene hydrochloride from pinene is now complete. It has been found possible by introducing improvements to raise the yield to 76%, the usual figure published being less than 60%. It has not been found possible to substantiate the claims made in patents for quantitative yields of camphene from pinene hydrochloride. The best yield we have obtained is 83%. It is hoped that the results of this work will provide a reliable guide to the value of the many published patents on the synthetic production of camphor from pinene and will indicate the best method for working on an industrial scale.

217. Condensation of methyl-o-toluidine and ethyl-o-toluidine with chloral hydrate.

A. N. MELDRUM and A. H. ADVANI, Bombay.

Methyl-o-toluidine and ethyl-o-toluidine were condensed with chloral hydrate to *p*-(α -hydroxy- β -trichloro ethyl)-o-methyl toluidine and *p*-(α -hydroxy- β -trichloro ethyl)-o-ethyl toluidine. These condensation products were converted into nitrosoamines by the action of nitrous acid. Acetyl derivatives were also prepared. The mono and diacetyl derivatives of the former yielded *p*-(β -dichloro-ethylene)-o-methyl aceto-toluidide on reduction with zinc dust and acetic acid.

Para-N-methyl-acetyl amino-m-toluic acid was also prepared from the diacetyl derivative; this on hydrolysis yielded *p*-N-methyl-amino-m-toluic acid which has been synthesised by J. Houben (Ber. 1909, 42, 4490).

218. Kinetics of heterogeneous organic reactions. The reactions between organic halogen compounds and solid inorganic salts.

K. E. LALKAKA and T. S. WHEELER, Bombay.

The kinetics of the reaction between benzyl chloride and solid silver nitrate in presence of inert solvents is being studied.

A preliminary qualitative study has been made of the action of solid nitrates on benzal chloride and bromide. Benzylidene nitrate is unstable and at once breaks down forming benzoic acid, a hydrogen atom

migrating from carbon to oxygen. Benzotrichloride and solid silver nitrate in the absence of water or other solvent give benzoic acid and a resinous substance. The hydrogen necessary for the formation of the acid appears to be derived in the production of the resin. Similarly dry triphenylchloromethane and solid silver nitrate give triphenylcarbinol and a resin.

219. The kinetics of heterogeneous organic reactions. A study of the benzoin reaction.

D. R. NADKARNI and T. S. WHEELER, Bombay.

Existing literature does not make it clear whether potassium cyanide and benzaldehyde in the absence of all solvents will yield benzoin. The discordant published results have now been traced to the fact that if pure benzaldehyde and pure potassium cyanide be employed, then benzoin in 99.6% yield can be obtained by shaking these reagents at room temperature for some days. The reaction is completely inhibited if less pure potassium cyanide be used. This inhibiting effect appears to be associated with the presence of calcium.

The kinetics of the heterogeneous reaction between potassium cyanide and benzaldehyde in the absence of all solvents has been studied at 100° and at 30°. The reaction is autocatalytic and is represented by

Rate of formation of benzoin

$$=k_1[\text{C}_6\text{H}_5\text{CHO}]^2 [\text{Benzoin}] + [\text{KCN}][\text{C}_6\text{H}_5\text{CHO}]^2$$

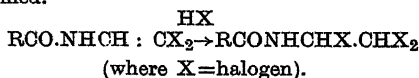
The main reaction is independent of the amount of KCN present. Addition of small quantities of water alters completely the kinetics of the reaction, which then becomes of zero order.

A new method has been worked out for estimating the quantity of benzoin formed in an experiment.

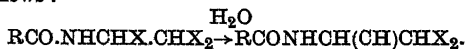
220. Study of the constitution of the reduction products of chloral and bromal amides.

B. H. YELBURGI and T. S. WHEELER, Bombay.

By the action of dry hydrogen chloride and also of hydrogen bromide on the reduction product of chloral and bromal amides addition compounds are obtained.



The compounds are unstable and on exposure gives a hydroxy compound as follows :—



That the compound obtained on hydrolysis is an hydroxy compound is shown by studying a number of derivatives.

All the evidence collected shows that the reduction products of chloral amide (RCO.NHCH(OH)CCl_3) are $\text{RCONHCH} : \text{CX}_2$ and not $\text{RCONHCH}_2\text{CHX}_2$ as hitherto supposed.

221. The gaseous equation of state.

T. S. WHEELER, Bombay.

In a recent paper (*Phil. Mag.*, 1932, 604) the author has shown theoretically that the second virial coefficient (B) of a gas of which the

molecules repel and attract one another by forces respectively $\frac{\lambda}{r^n}$ and $\frac{\mu}{r^m}$ can be expressed by an equation of the form

$$B = C_1 \left(\frac{\lambda}{T} \right)^{\frac{3}{n-1}} + C_2 \left(\frac{\mu}{T} \right)^{\frac{3}{m-1}}$$

This equation has now been applied to calculate the second virial coefficients of helium, neon, argon, hydrogen and nitrogen with satisfactory results. The relation of this expression to the more complicated expression of Lennard-Jones

$$B = K \left[\left(\frac{\lambda}{T} \right) \left(\frac{T}{\mu} \right) \right]^{\frac{3}{n-m}} F \left[\left(\frac{\mu}{T} \right) \left(\frac{T}{\lambda} \right)^{\frac{m-1}{n-1}} \right]$$

is being examined.

222. Action of nitric acid on (1) p-(α -hydroxy- β -trichloro ethyl)-o-methyl toluidine; (2) p-(α -hydroxy- β -trichloro ethyl)-o-ethyl toluidine; (3) p-(α -hydroxy- β -trichloro ethyl)-dimethyl aniline and the action of bromine on the first two compounds.

A. H. ADVANI and T. S. WHEELER, Bombay.

The first two condensation products on treatment with strong nitric acid in the cold yielded the *mononitro compounds*. When the reaction was allowed to proceed in warm nitric acid, in both the instances, *nitro-nitramino* were obtained. The mononitro compounds yielded *diacetyl derivatives* whereas the dinitro compounds yielded *monoacetyl derivatives*.

The dinitro compound from the first condensation product, on exhaustive nitration yielded a known substance:—4:6-trinitro-methyl toluidine melting at 119° (Annalen 1905, 339, 221) which on treatment with strong sulphuric acid gave a *nitrosoamine*. The dinitro compound also yielded a *nitro-nitramino carboxylic acid*.

Para-(α -hydroxy- β -trichloro ethyl) dimethyl-aniline on nitration in the cold yielded the corresponding di-nitro compound and in warm nitric acid gave a *nitro-nitramino chloral compound*. The condensation product on exhaustive nitration gave a known substance 2:4:6 trinitro-N-methyl-nitraniline (R., 1883, 2, 108, 305). The first two products of nitration gave each a *monoacetyl derivative*.

The first two condensation products on bromination yielded *mono-bromo compounds* whilst each of these compounds gave a *diacetyl derivative*. The diacetyl derivative of the former on oxidation was converted into a *bromo-monobasic acid* melting at 201°.

Further work is in progress on the bromination of all the three condensation products and the action of phosphorus pentachloride on the nitration products mentioned above.

223. Effect of temperature on the formation of salicylic acid derivatives.

N. W. HIRVE, Bombay.

On sulphonating salicylic acid, 5-nitro-salicylic acid alone was obtained by (a) Mendius (A., 1857, 103, 45), by (b) Remsen (A., 1875, 179, 137); by (c) Hirsch (Ber., 1900, 33, 3239); and by (d) Meldrum and Shah (Soc., 1923, 1986).

As heat is developed on addition of sulphuric acid to salicylic acid, the sulphonation was always carried out at high temperature and some even heated the mixture to 100° and above.

Having obtained 3-sulpho-salicylic acid indirectly from 5-nitro-3-sulpho-salicylic acid, and having found a great difference in the solubility in water of the acid potassium salts of 3-sulpho- and 5-sulpho-salicylic acids, the method was successfully applied to the isolation of 3-sulpho-salicylic acid from the reaction mixture in small quantities.

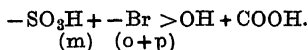
Low temperature favours the formation of 3-sulpho-salicylic acid; but the time required for the reaction to be complete is long. At high temperatures the reaction is finished quicker, but the main product is 5-sulpho-salicylic acid. The actual yields have been studied at various temperatures.

224. Stability of sulphonic acid group in the 4-sulpho-salicylic acid.

N. W. HIRVE and M. R. JAMBHEKAR, Bombay.

4-sulpho-salicylic acid has been nitrated and brominated and it has been shown that not only mono-nitro-sulpho and mono-bromo-sulpho-salicylic acids are obtained but also a dinitro-sulpho and a dibromo-sulpho-salicylic acid. This shows the unusual stability of the sulphonic acid group in position *four*, since the sulphonic acid group in 3-sulpho- as well as in 5-sulpho-salicylic acids is very easily eliminated either on bromination or nitration to give a 3 : 5 dibromo or 3 : 5 dinitro-salicylic acid.

Even on further action of bromine on 4-sulpho-salicylic acid a tri-bromo-sulpho-salicylic acid is obtained. This shows that the directing influence of

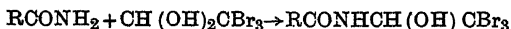


The various nitro-sulpho-, amino-sulpho- and bromo-sulpho-salicylic acids and their derivatives are described.

225. Condensation of bromal with aliphatic amides.

B. H. YELBURGI, Bombay.

Bromal hydrate was condensed with the aliphatic amides—from formamide to pelargonamide. The condensation took place as follows and bromal amides were obtained.



The condensation products were further reduced with zinc and acetic acid. In cases where the condensation products could not be directly reduced, their acetyl derivatives were reduced.

Various derivatives like acetyl and benzoyl were prepared.

226. Condensation of ethyl propyl acetoacetate with aromatic amines. Part II.

G. V. JADHAV, Bombay.

It has been shown in Part I (*J. Ind. Chem. Soc.*, 1931, 8, 681), that simple aromatic amines give simple anilides as well as carbamide derivatives according to the conditions of the reaction. The work is being extended to determine the effect of the substitution of a hydrogen atom of the amine by more negative groups like $-\text{NO}_2$ or Cl . *o*-, *m*-, *p*-chloranilines and *p*- and *m*-nitranilines have been used. It has been found that

in all cases a simple anilide as well as a carbamide derivative are obtained according to the conditions of the reaction.

The constitution of the carbamide derivatives has been confirmed by their preparation according to Guha and Mistry (*J. Ind. Chem. Soc.*, 1930, 7, 793), as well as by converting them into simple acetchlor- or acetnitro-anilides by boiling them with acetic anhydride and fused sodium acetate.

227. Bromination of aromatic acid derivatives.

G. V. JADHAV and Y. I. RANGWALLA, Bombay.

It has been known that simple aromatic acids cannot be easily brominated and most of their bromo derivatives are obtained indirectly. M-bromobenzoic acid is obtained by direct bromination after heating benzoic acid and bromine in presence of water in a sealed tube for several hours. (Hübner, Ohly, and Phillip. *Annalen*, 1867, 145, 233; Hübner and Peterman. *Annalen*, 1894, 281, 2461.)

The work was undertaken to examine the distribution of bromine in esters containing two phenyl groups substituted in different ways.

The p-nitrophenyl benzoate resisted the action of bromine alone or in the presence of a solvent as well as usual catalysts like iodine, zinc chloride or anhydrous aluminium chloride. The method of Varma and Kulkarni (*J. Ind. Chem. Soc.*, 1926, 3, 291) was therefore applied and bromination was tried in the presence of nitric acid as well as fuming nitric acid, when in the latter case a nitro derivative in addition to the bromo compound was obtained. The bromo compound is p-nitrophenyl-m-bromobenzoate. The isolation of the bromo compound is difficult due to practically the same solubility as that of the original ester in the same solvent. Similarly the o-nitro-phenyl-benzoate gives two products. The work is being extended.

228. Condensation of phenols with acetone-dicarboxylic ester in presence of phosphorus pentoxide.

D. CHAKRAVARTI, Calcutta.

In continuation of the work in this line by the author (*J. Ind. Chem. Soc.*, 1931, 8, 129, 407, 619; 1932, 9, 25, 31, 389), it has been found that poly-hydroxy-phenols, e.g. resorcinol, orcinol, pyrogallol, etc. condense with acetone-dicarboxylic ester in presence of phosphorus pentoxide to form not chromones (as would be expected from Simonis' reaction) but coumarins, identical with the compounds, prepared by Dey (*J. Ind. Chem. Soc.*, 1915, 107, 1606) in presence of sulphuric acid. The condensation of the mono-hydric phenols, e.g. cresols, nitro-phenols and chloro-phenols, with acetone-dicarboxylic ester in presence of phosphorus pentoxide, is attended with difficulties, but interesting results are expected.

229. Friedel Crafts reaction with methoxy-coumarins and acid chlorides.

D. CHAKRAVARTI, Calcutta.

Methoxy-coumarins, e.g. 7-methoxy-4-methyl-coumarin, have been found to condense with acyl-chlorides in presence of aluminium chloride to form ketones. Attempts are being made to synthesise Coumaro- γ -pyrones, where one α -pyrone and one γ -pyrone ring are attached to the same benzene nucleus (Cf. Sen and Chakravarti, *Proc. Ind. Sc. Congress*, 1931, p. 158), from these ortho-hydroxy-coumaryl-ketones.

230. Observations on the chemistry of the B-Vitamins.

B. C. GUHA and P. N. CHAKRAVARTY, Calcutta.

Certain researches carried out lately on Vitamin B₁ indicate that it is probably a purine derivative. Progress has been made in the concentration of Vitamin B₂, starting from Ox kidney or Ox liver. The process involves adsorption of the B₂ factor by charcoal and its subsequent elution by HCl. The chemical behaviour of vitamin B₂ suggests that it is a simple molecule, having neither pronouncedly acidic nor basic properties. The investigation is being continued.

231. Action of (a) Potassium chlorate and (b) Potassium bromate on Iodine.

M. S. SHAH and S. S. DESAI, Ahmedabad.

The reactions between (a) potassium chlorate and iodine, and (b) potassium bromate and iodine have been studied quantitatively with varying amounts of the reactants in absence and presence of traces of different acids such as sulphuric acid, nitric acid, hydrochloric acid, and acetic acid.

The reaction (a) proceeds in accordance with Bassett's equation: $6\text{I}_2 + 10\text{KClO}_3 + 6\text{H}_2\text{O} = 6\text{KH}(\text{IO}_3)_2 + 4\text{KCl} + 6\text{HCl}$ (*J.C.S.*, 1890, 57, 761), only in presence of an acid and is totally inhibited when the acid is absent. The reaction (b), on the other hand, proceeds whether an acid is present or absent according to $\text{I}_2 + 2\text{KBrO}_3 = 2\text{KIO}_3 + \text{Br}_2$.

The authors have also studied the action of hydrochloric acid, hydrobromic acid and hydriodic acid at different dilutions on potassium chlorate, potassium bromate, and potassium iodate. The results obtained throw light on the mechanism involved in the above-mentioned reactions.

232. Applications of the methylsulphone method in proving the constitutions of substituted benzene sulphonc acids.

M. S. SHAH, C. T. BHATT, and D. D. KANGA, Ahmedabad.

The authors have shown previously (*Proc. Ind. Sc. Cong.*, 1931, p. 152) that methoxytoluene-sulphonic acids and sulphomethoxy-benzoic acids give *via* sulphonylchlorides, thiols and methylthiols, identical methoxybenzoic acid methylsulphones possessing definite crystalline forms and sharp melting points. With the help of the latter numerous substituted benzene sulphonc acids could be identified. The formation of methylsulphone constitutes a general method, alternative to that of sulphonamide, in determining the constitutions of sulphonc acids. Two applications of the method are given below:—

1. The nitrosulpho-benzoic acid obtained on sulphonation of benzoic acid followed by nitration (Limpricht and Uslar, *Annalen*, 1858, 106, 27; Taverne, *Rec. Trav. Chim.*, 1906, 25, 50) is 5-sulpho-3-nitrobenzoic acid since it produces through 5-sulpho-3-hydroxy-benzoic acid, 5-sulphonamido-3-methoxy-benzoic acid, m.p. 214°, and 3-methoxybenzoic acid 5-methyl-sulphone, m.p. 195°.

2. The product obtained on sulphonating m-toluidine is m-toluidine-6-sulphonic acid and not m-toluidine-2-sulphonic acid as described by Limpricht (*Ber.*, 1874, 7, 448) and Lorenz (*Annalen*, 172, 177) since the amino-sulphonic acids yields *via* 3-methoxytoluene-6-sulphonic acid, 5-methoxy-o-benzoic-sulphinimide, m.p. 242°, and 3-methoxy-benzoic acid 6-methyl-sulphone, m.p. 180°.

233. Condensation of chloral with 2-hydroxy-p-toluic acid and its methyl ether.

B. M. KAPADIA and A. N. MELDRUM, Bombay.

The authors have obtained the chloral derivatives of 2-hydroxy-p-toluic acid and its methyl-ether.

The main reactions are: (A) Condensation of chloral with (1) $\text{C}_6\text{H}_3\text{CH}_3\text{OH} \cdot \text{COOH}$ and (2) $\text{C}_6\text{H}_3\text{CH}_3\text{OCH}_3\text{COOH}$; so as to get (3) $\text{C}_6\text{H}_2\text{CH}_3\text{OH}(\text{CHCCl}_3)\text{CO}$ and (4) $\text{C}_6\text{H}_2\text{CH}_3\text{OCH}_3\text{CO}(\text{CHCCl}_3)$. (B) Reduction of condensation product with zinc and acetic acid so as to get (5) $\text{C}_6\text{H}_2\text{CH}_3\text{OH} \cdot (\text{CH}_2\text{CHCl}_2)\text{COOH}$ and (6) $\text{C}_6\text{H}_2\text{CH}_3\text{OCH}_3\text{COOH}(\text{CH}_2 \cdot \text{CHCl}_2)$. (C) Simultaneous hydrolysis and oxidation of the reduction product with sulphuric acid (conc.); the reaction converted compound (5) into (7) $\text{C}_6\text{H}_2\text{CH}_3\text{OH}(\text{CH}_2\text{COOH}) \cdot \text{COOH}$ and compound (6) into (8) $\text{C}_6\text{H}_2\text{CH}_3\text{OCH}_3\text{COOH}(\text{CH}_2\text{COOH})$ (note that OCH_3 group is simultaneously hydrolysed and compound (7) and (8) are different which is further proved by the m.p. of their mixture which is 200° and also as follows:—

Compound (7) was further condensed with chloral when (9) $\text{C}_6\text{H}_3\text{CH}_3\text{OH} \cdot (\text{CH}_2\text{COOH})\text{CO} \cdot \text{CHCCl}_3$ was obtained while compound (8) gave

quite remarkably (10) $\text{C}_6\text{H}_2\text{CH}_3\text{OHCOOH} \cdot \text{CH}_3$. Compound (9) was reduced to get (11) $\text{C}_6\text{HCH}_3\text{OH}(\text{CH}_2\text{COOH})\text{COOH}(\text{CH}_2\text{CHCl}_2)$

m.p. 202° – 205° $\xrightarrow[\text{and oxidation with H}_2\text{SO}_4]{\text{Hydrolysis}}$ $\text{C}_6\text{H} \cdot \text{CH}_3 \cdot \text{OH}(\text{CH}_2\text{COOH}) \cdot \text{COOH}(\text{CH}_2\text{COOH})$ m.p. 220° .

The action of sodium hydroxide solution on compound (3) gave (13) $\text{C}_6\text{H}_2\text{CH}_3\text{OH} [\text{CH}(\text{OH})\text{COOH}] \text{COOH}$ m.p. 115° and on (9) gave (14) $\text{C}_6\text{H} \cdot \text{CH}_3\text{OH}(\text{CH}_2\text{COOH})\text{COOH}[\text{CHOHCOOH}]$ m.p. 246° but the methyl ether compound (4) gave (15) $\text{C}_6\text{H}_2\text{CH}_3\text{OCH}_3 \cdot \text{COCHCOOH}$.

Acetaldehyde derivatives were produced by the action of alkali on the reduction compounds (5) and (6). The result is unconfirmed.

It should be noted here that the $-\text{OH}$ group directs the condensation in ortho-position while the $-\text{OCH}_3$ group directs it in the para-position alone.

234. A new synthesis of thio-ethers of hydroxy aromatic acids.

N. W. HIRVE, G. V. JADHAV, and Y. M. CHAKRADEO,
Bombay.

Thionyl chloride acts on phenol and resorcinol, producing sulphides and sulphoxides. The reaction is vigorous even in the cold. With salicylic acid (o-hydroxy benzoic acid) the reaction of thionyl chloride produces all types of different anhydro compounds, possibly by the condensation of $-\text{OH}$ and $-\text{COOH}$ groups. The $-\text{COOH}$ group was protected by converting it into its methyl ester $-\text{COOCH}_3$, and thus the methyl salicylate was treated with thionyl chloride alone. In the cold

there is no reaction, while on boiling for a long time, a high boiling liquid is obtained.

The reaction was also tried in the presence of finely divided copper which was converted into copper chloride and a di-methylsalicylate-thio-ether was obtained.

By bromination di-3-bromo-methylsalicylate-thio-ether is obtained, which gives 3-bromo-5-nitro-methylsalicylate by the action of nitric acid.

Similar condensations have been tried with the methyl esters of m-cresotinic acid, o-cresotinic acid, and 4-methoxy salicylic acid. Various derivatives of these condensation products also have been obtained.

235. Hydrogenation of common Indian oils.

M. S. PATEL and B. S. KANVINDE, Bombay.

The present investigation was undertaken to work out suitable data for the manufacture of tallow substitute by studying the hydrogenation of common Indian oils treated alone or in mixture in various proportions.

The rate of hydrogenation of groundnut oil is accelerated with the increase in the catalytic concentration. It is also found that at later stages the rate is almost proportional to the concentration of the catalyst.

In the case of supported catalyst, the temperature of reduction has considerable influence on the activity of the catalyst. A catalyst with 28.57% nickel on support when reduced at 500°C. is very active. The same catalyst when reduced at 320°C. is much less active. In spite of the larger area of the surface, its activity is found to be less than that of the corresponding unsupported nickel.

A supported catalyst containing about 28% nickel on support was found to be more active than that with 16% nickel.

In the hydrogenation of groundnut oil with low catalytic concentration the selectivity is exhibited more prominently than with higher catalytic concentration or with catalysts of high activity.

The melting point of groundnut oil at any particular degree of hydrogenation is the same irrespective of the nature and the concentration of the catalyst used during the hydrogenation.

The mixtures of oil consisting of glycerides of similar nature have in general a mean course of behaviour during hydrogenation with relation to the pure individual oils.

236. Starch and oil from Jowar (*Sorghum Vulgaris*).

M. S. PATEL and K. P. SHAH, Bombay.

The object of the work was to find out a suitable process for the extraction of starch from Jowar, to determine the exact conditions for obtaining maximum yields, and to study the nature of the bye-products.

The work has been completed and the results can be summarised as follows :—

1. Out of all the processes for the manufacture of starch from cereals the sulphurous acid process is found to be the most suitable for producing starch from Jowar. By this method the yields obtained are very high (about 52%) and the quality of the starch is good.

2. The traces of gluten in the final product (starch) could be removed by a weak solution of ammonia.

3. The slightly dull tinge of the starch obtained could be removed by bleaching. Passing chlorine gas into a thick suspension of starch in water is found to work better than solutions of sodium hypochlorite and bleaching powder.

4. It is difficult to separate the germs completely from the grain by flotation. It will be necessary to work some other process for this purpose.

5. The gelatinisation temperature of Jowar starch is 67°C.
6. Jowar starch granules are polygonal in shape and larger in size than those of the maize and rice starch.
7. The Jowar starch gave a good paste without any grit and acted as a good binding material for the size. The starch gets desized very easily.
8. The viscosity measurements showed that Jowar starch resembled wheat in its paste forming qualities.
9. The waste bran obtained after separation of starch from Jowar about 11% protein matter which compares favourably with the other cattle feeds.
10. The oil obtained from the germs of the Jowar grain is semi-drying oil resembling maize oil in its properties. Like the maize oil Jowar oil can be put to a number of uses: It has the following characteristics:—

Colour	Golden yellow
Solidifying point	— 8° to — 9°C.
Specific gravity	0.910 at 28°C.
Refractive Index	1.467 at 28°C.
Sap. Value	173.2
Iodine Value	126.8
Unaponifiable matter	7.9%
Iodine value of the mixed fatty acids			130
Neutralisation value of the mixed fatty acids	166.5
Saponification value of the mixed fatty acids	186.1

237. Preparation of thorium nitrate and cerium nitrate from Indian monozite sand.

M. S. PATEL and S. G. DEV, Bombay.

The manufacture of Thorium nitrate and allied salts is a closely guarded secret. Recently demand for Thorium and Cerium nitrates has been created in this Presidency due to the development of gas mantle industry. There is however an international organization of gas mantle manufacturers which does not allow the sale of chemicals used in mantle industry to parties outside their pool, and so it is almost impossible for Indian gas mantle manufacturers to get their supplies of Thorium and Cerium nitrates. This work has been therefore undertaken to find out an economic process for the manufacture of these salts, from Indian Monozite sand. Samples of the sand have been analysed and have been found to contain 4 to 9.5% Thorium oxide.

238. Extraction of saponin from (1) soap-nuts (*Sapindus Trifoliatus*), (2) soap-pods (*Acacia Concina*).

M. S. PATEL and M. C. LAIWALA, Bombay.

To find out a suitable method for the economic extraction of saponins which are used in large quantity in textile and beverage industry.

The pericarp of soap-nuts was found to constitute about 58% of the entire nut and the seed the rest. The pericarp on exhaustion with re-distilled methylated spirit yielded an extract which was treated with lead acetate and the lead salt of saponin decomposed with H₂S. The crude saponin thus obtained has been purified. The yield of saponin was found to be 6.8% of the pericarp. Further work is in progress.

239. Extraction and purification of strychnine and brucine from *Nux Vomica*.

M. S. PATEL and G. B. RAU, Bombay.

The *Nux Vomica* seeds which are found in abundance in India are exported in large quantities to foreign countries where they are used in the manufacture of Strychnine. This investigation has been undertaken to find out a cheap method suitable to Indian conditions by which the alkaloids can be manufactured from *Nux Vomica* seeds in this Presidency. The seeds have been extracted (1) with lime and methylated spirit, (2) with 40% redistilled methylated spirit.

It was found that the yield of alkaloids increased with the increase in the amount of lime up to 25% of the weight of the seeds. It was, however, found that by the lime process the separation of the alkaloids from the extract was difficult. With 40% methylated spirit the alkaloids could be separated easily.

Mixtures of Strychnine and Brucine have been isolated and the separation of the alkaloids is in progress.

240. Extraction of cellulose from rice straw.

M. S. PATEL and B. B. SARDESHPANDE, Bombay.

The object of the present work is to obtain proper data as to the yield of cellulose from Bombay rice straw under various conditions of alkali concentration, temperature and time of digestion, and to find out whether it is possible to prepare paper and allied products from the cellulose obtained from Bombay rice straw.

The results can be summarised as follows :—

(1) The moisture content of the rice straw varies with the atmospheric conditions. It is highest in the rainy season. Bombay rice straw contains 48 to 55% total celluloses. Out of this 34 to 37% is alpha cellulose and the rest beta and gamma celluloses.

(2) The liquors obtained after the separation of the first and the second groups stains a bleached piece of cloth. The stain is not capable of being removed even by bleaching.

(3) In actual mill produce the yield of cellulose from Bombay rice straw should be about 36 to 37%.

(4) 140°C. is about the best temperature for the digestion of the straw.

(5) For the production of fairly good cellulose the concentration of the alkali ought to be much higher than the 3%.

(6) Under proper conditions of temperature and alkali concentration the period of digestion should be about 1½ hours.

(7) Total alkali required for complete digestion of the Bombay rice straw is 10.5%.

(8) Total amount of bleaching powder required for the bleaching of the cellulose is 4.5% calculated as CaOCl_2 .

(9) The fibres of rice straw resemble those of esparto in many respects. The cellulose obtained from rice straw is quite suitable for the manufacture of paper and allied products.

(10) As the fibres of rice straw are shorter in length they have to be mixed with a small percentage of cellulose with longer fibres for ordinary paper making purposes.

Samples of paper have been prepared from the cellulose obtained during the investigation and these have been favourably reported upon by paper-makers.

241. Preparation of alumina and aluminium sulphate, from Indian bauxite.

M. S. PATEL and G. K. OGALE, Bombay.

Indian bauxite contains a considerable amount of silica and titanium in addition to iron. Both these impurities prevent the profitable extraction of Al_2O_3 from Indian bauxite by the Bayer process. The present investigation is undertaken to find out a suitable economic process for the preparation of alumina or aluminium sulphate or both from Indian bauxite. Samples of bauxite have been analysed. One sample having the following composition is being investigated :—

Al_2O_3	56%
Fe_2O_3	8.5%
TiO_2	6.5%
SiO_2	5%

Solubility of Al_2O_3 and Fe_2O_3 and TiO_2 in acids is being determined under various conditions. It has been found that heating the bauxite at 110°C . for 1 hour prior to treatment increases the solubility of Fe_2O_3 and TiO_2 in HCl and decreases that of Al_2O_3 in the same acid.

242. Extraction of sodium carbonate and sodium bicarbonate from efflorescent natural soda.

M. S. PATEL and P. S. RAO, Bombay.

Efflorescent natural soda is produced at various localities in this presidency which is utilised for the manufacture of soap by crude methods. This investigation has been undertaken to work out sufficient data to enable one to evolve a suitable process by which Sodium carbonate and bicarbonate can be extracted from the natural soda by simple and economic means.

Samples of natural soda have been collected and analysed. They are found to contain :—

Sample.	Na_2CO_3	NaHCO_3	NaCl	Na_2SO_4	Insoluble residue.
(A) Prantij ..	25.66%	4.22%	1.65%	..	69.9%
(B) Kapadvanj ..	20.54%	..	2.19%	..	78.8%
(C) Bhavanagar ..	12.11%	6.73%	81.5%
(D) Sindh ..	15%	9.3%	8.7%	7.5%	59.7%

The study of the solubility of the following two systems has been undertaken.

(1) Na_2CO_3 NaHCO_3 NaCl Na_2SO_4

(2) " " " —

Equilibrium has been determined at 29° , 33° , 40° , 60° , 65° , and 80°C .

The solubility of Na_2CO_3 in the presence of the other three salts decreases up to 40°C . and then increases.

The solubility of NaHCO_3 increases with the rise in temperature.

The solubility of Na_2SO_4 decreases up to 33°C . and then increases again.

There is only a slight increase in the solubility of NaCl with rise in temperature in presence of the other salts.

243. Some new photo-sensitizers.

G. GOPALA RAO, Waltair.

Of the oxides, only zinc oxide has so far been described to possess marked photo-sensitizing activity. It is now found that ignited cadmium

oxide and titanium dioxide are also powerful photo-sensitizers. Cadmium oxide has been studied in detail. It sensitizes the following reactions in ordinary sunlight :—(1) the decomposition of silver nitrate; (2) the bleaching of various dyes in the presence of glycerine; (3) the formation of hydrogen peroxide from water and air; (4) the oxidation of ammonia and its salts to nitrite; (5) the hydrolytic decomposition and oxidation of various nitrogenous substances like urea, the amides, amines, amino-acid, etc. Titanium dioxide is a powerful photo-sensitizer for reactions 4 and 5.

244. The rôle of sodium sulphite in photographic developers.

G. GOPALA RAO and K. M. PANDALAI, Waltair.

Photographic developing solutions contain one or two reducing substances like metol, pyrogallol, or hydroquinone, and a large amount of sodium sulphite with some sodium carbonate. The part played by sodium sulphite has not yet been adequately explained.

Mortan (*Radiation in Chemistry*) states that sodium sulphite probably prevents the loss of hydroquinone by atmospheric autoxidation, hence more of the hydroquinone would be available for reducing the silver halides in the presence of sodium sulphite than in its absence. Dhar has suggested that this is an induced reaction. It is here shown that Mortan's view was untenable and that the above one was really an induced reaction, the reduction of silver halides by hydroquinone inducing the reaction between sodium sulphite and silver halides.

245. A new synthesis of methyl rhizonate.

R. C. SHAH, Bombay.

Rhizonic acid obtained as a decomposition product of various lichen acids, is 2-hydroxy-4-methoxy-3:6-dimethyl-benzoic acid. The acid and its derivatives have been previously synthesised by methods which are long and difficult. The author has now synthesised methyl rhizonate directly from orcinol which was converted into orsenillic acid by the method of Hoesch (*Ber.*, 1913, 46, 886) through oreylaldehyde and subsequent oxidation of its dicarbomethoxy derivative. Orsenillic acid was converted into its methyl ester by means of diazomethane. Methyl orsenillate when methylated by means of KOH and MeI under proper conditions directly gave methyl rhizonate which is insoluble in dilute alkali and gives a deep violet coloration with ferric chloride.

246. The chemistry of imido-chlorides. Part II. Reaction of benzanilide-imido-chloride with n-dimethyl o-m- and p-toluidines in the presence of anhydrous aluminium chloride as condensing agent.

R. C. SHAH and N. B. ITOHHAPORIA, Bombay.

In part I, a new and direct synthesis of p-dialkylamino benzophenones by condensation of benzanilide-imido-chlorides with dimethyl- and diethylanilines in presence of anhydrous aluminium chloride has been described (Shah and Chaubal, *J.C.S.*, 1932, p. 650). This reaction has been now extended to dimethyl-o-toluidine, dimethyl-m-toluidine, and dimethyl-p-toluidine in order to establish the general applicability of this convenient synthesis, and to study the influence of substituents in the dialkylaniline.

Shah and Chaubal's original method has been improved upon by the use of dry ether, which has been found to have the valuable property of readily dissolving anhydrous aluminium chloride, in place of carbon.

disulphide or benzene, as solvent. The resulting ketones, 3-methyl-4-dimethylamino-benzophenone, 2-methyl-4-dimethylamino-benzophenone and 5-methyl-2-dimethylamino-benzophenone are new, the condensation taking place in the para position to the dimethylamino group in the first two cases and in the ortho-position in the third.

It is interesting to note that 3-methyl-4-dimethylamino-benzophenone easily obtained in the present work from dimethyl-o-toluidine, cannot be prepared by the older method from dimethyl-orthotoluidine benzanilide and phosphorus oxychloride (Meisenheimer, *Annalen*, 1921, 423, 75). Interesting observations have been made regarding the influence of steric hindrance in the condensations and in the formation of the oximes and methiodides of the ketones.

247. The chemistry of imido-chlorides. Part III. A synthesis of quinoline derivatives.

R. C. SHAH and V. R. HEERAMANICK, Bombay.

The formation of a quinoline derivative, ethyl 4-hydroxy-2-phenyl-quinoline-3-carboxylate by heating the condensation product of benzanilide-imido-chloride and ethyl malonate was first observed by Just (*Ber.*, 1886, 19, 149, 161) who studied only a few cases of this kind. A systematic investigation of this reaction is being carried out. The original method of condensation has been improved upon, by the use of two mols. of malonic ester instead of one which increases the yield and the purity of the required mono-condensation product. Ring closure has also been brought about by a new method, viz. by means of sulphuric acid.

The following new compounds have been prepared.

Ethyl-p-nitro-anil-benzenyl malonate, ethyl-(4-hydroxy-2-p-nitrophenyl-quinoline-3-carboxylate, ethyl-o-chloro-anil-benzenyl malonate, ethyl-4-hydroxy-2-chloro-phenyl-quinoline-3-carboxylate, ethyl-anil-m-nitro-benzenyl-malonate, ethyl-anil-p-nitro-benzenyl malonate, ethyl-4-hydroxy-2-phenyl-6-nitro-quinoline-3-carboxylate, ethyl-4-hydroxy-2-phenyl-8-methyl-quinoline-3-carboxylate, ethyl anil-m-methyl-benzenyl-malonate.

The work is being continued.

248. A new synthesis of 2 : 4-dihydroxy-benzophenone.

R. C. SHAH and P. R. MEHTA, Bombay.

Benzanilides condense with dimethylaniline in the presence of phosphorus oxychloride to give keto-anils which are readily hydrolysed giving dimethyl-amino-benzophenones (Meisenheimer, *Annalen*, 1921, 423, 75; Shah, Deshpande and Chaubal, *J.C.S.*, 1932, 642).

An attempt to condense benzanilide with resorcinol in the presence of phosphorus oxychloride on similar lines was unsuccessful, the benzanilide remaining unchanged. It has been found however that benzanilide readily condenses with resorcinol with a mixture of phosphorus oxychloride and anhydrous zinc chloride as condensing agent, giving finally 2 : 4-dihydroxy-benzophenone in good yield. The condensation takes place more smoothly and the yield of the ketone is further improved when benzanilide is replaced by benzamide.

The method gives a much better yield of 2 : 4-dihydroxy-benzophenone than the known method in which benzoic acid is condensed with resorcinol with the help of anhydrous zinc chloride. Benzanilide has been similarly condensed with orcinol and β -naphthol. The work is being extended.

249. On the study of polyhalides, Part II. Formation and dissociation of chloro-dibromides, and tribromides of sodium, potassium, strontium, and barium.

S. K. RAY, Calcutta.

In continuation of the previous work (*Jour. Indian Chem Soc.*, 1932, 9, 259) the formation and dissociation of the polyhalides of sodium, potassium, strontium, and barium have been studied by the freezing point method. The constancy of the value of the equilibrium constants, calculated from the freezing point depressions, conclusively proves the formation of the polyhalides. The actual isolation of the complex polyhalides has been possible in some cases.

250. Induced (slow) and photo-chemical oxidation of glucose in presence of glutathione.

C. C. PALIT and N. R. DHAR, Allahabad.

Induced (slow) oxidation.—1. Experiments show that there is more oxidation of glucose in presence of glutathione and sodium phosphate than with phosphate alone, showing that glutathione acts as an inductor in the oxidation of glucose in presence of phosphate and that with a definite amount of glutathione, the amount of oxidation of glucose increases with the increase of phosphate.

2. With sodium bicarbonate, the amount of glucose oxidised is also greater in presence of glutathione than in its absence, but with sodium carbonate and sodium sulphite respectively, the results obtained are quite the reverse. Also there is more oxidation of glucose in presence of sodium carbonate or sodium sulphite alone than in presence of either of these and glutathione together.

Photo-chemical oxidation in sunlight.—1. Experiments show that (a) the amount of oxidation of glucose increases with the increase of sodium phosphate, whether the oxidation occurs in presence or absence of glutathione, (b) the amount of oxidation of glucose with phosphate in presence of glutathione is greater than in its absence under similar conditions, and (c) the oxidation of glucose increases as the amount of glutathione increases.

2. In presence of sensitisers such as uranium nitrate, ferric nitrate, zincoxide, animal charcoal, etc., oxidation of glucose in presence of glutathione is greater than in its absence and the order in which it is oxidised is uranium nitrate > ferric nitrate > zincoxide > animal charcoal.

3. Photo-chemical oxidation of glucose with sodium bicarbonate is greater in presence of glutathione than in its absence, while with sodium carbonate the results are quite the reverse like the results obtained in case of induced oxidation.

Section of Zoology.

President :—R. GOPALA AIYAR, M.A., M.Sc.

Presidential Address.

SOME ASPECTS OF MARINE BIOLOGICAL RESEARCH.

Introduction.—When I received the invitation of the Executive Committee of the Science Congress to serve as the President of the Zoology Section for this year I was surprised and no less flattered that an honour of this kind should have been extended to an humble worker like myself. I have attended most of the sessions of the Science Congress and I know the many illustrious gentlemen who have filled this chair with signal distinction. As remarked by a previous President of this section, I should attribute this honour to the great sympathy and fraternity existing among the Zoologists of this country and to their desire to honour workers however humble they may be.

In the choice of my subject, I have naturally been governed by a desire to stick to a field in which I am interested and leave aside other pastures however tempting. Even here, I can speak as a scribe only and not as one with authority. Marine Biology is and has been treated as a part of the bigger Science of Oceanography which received such able treatment at the hands of Prof. Mathai at the Lucknow session in the year 1923. Though it is not possible to keep the two sciences strictly separate, I shall confine my observations, as far as possible, to Marine Biology without encroaching upon the bigger and more comprehensive science of Oceanography. When Pytheas sailed between the Pillars of Hercules in the 4th century B.C., and passed into the vast Atlantic and penetrated into the British Seas 'thick and sluggish' like a jelly fish he was probably recording a planktonic observation. The versatile Aristotle who took all sciences as his special subject was a keen observer of marine life. Coming to more recent times, Oceanographers like Captain James Cook who sailed to the South Pacific in 1769 with Sir Joseph Banks as naturalist on board, and Sir James Clark Ross who with Sir Joseph Hooker as naturalist first dredged the Atlantic in 1840, added considerably to our knowledge of Marine Biology. O. F. Müller, who extensively used the naturalist's dredge in 1799 in the Danish waters started a line of work which has led to very far-reaching results. The work with the dredge was continued by Milne-Edwards in France (1830), Edward Forbes in England (1832), and Michael Sars in

Norway (1835). The second, a Manx man, whose noble bust stands at the entrance to the Port Erin Biological Station in memory of his great work may, in some respects, be regarded as a pioneer in Oceanography, though the term itself was coined later by Sir John Murray in 1880. His constant use of the dredge added greatly to the knowledge of the British marine animals. His work, together with the work of such naturalists as Wyville Thomson, Carpenter, and Norman paved the way to the great '*Challenger*' and other expeditions. Edward Forbes, basing his study on the marine organisms of the shore, divided the shore line into various zones and postulated the existence of an azoic zone below the three hundred fathom line. It was left to Sir Wyville Thomson and his colleague Carpenter, who as a result of their work on board the deep-sea exploration steamers the '*Lightning*' and the '*Porcupine*', proved the entire fallacy of the assumption of Forbes, of an azoic zone.

Efficient apparatus to investigate the Ocean was rapidly perfected during the voyages of the '*Lightning*' and the '*Porcupine*', so much so that when the '*Challenger*' set out on her great venture (1872-76) she was already in possession of apparatus sufficiently useful to reap the rich harvest of the seas. Other nations, fired with enthusiasm and imbued with a thirst for scientific knowledge, sent out their expeditions in quick succession. The '*Valdivia*' (1878-79) in the Atlantic and Indian under Chun, the '*Investigator*' (1881-1926) in the Indian Seas, the '*Hirondelle*' and the '*Princesse Alice*' in the Mediterranean and the North Atlantic, '*Blake*' and '*Albatross*' (1887-90) in the Atlantic and Pacific under Agassiz, '*The National Plankton Expedition*' (1889) in the North Atlantic under Hensen, the '*Ingolf*' (1895-96) in the North Atlantic and the Mediterranean, the '*Siboga*' (1899-1900) in the East Indies and in the 20th century the '*Deutschland*' (1911) in South Polar and Atlantic with Lohman on board, '*Michael Sars*' (1910) under Hjort and Murray who financed the expedition, '*Dana*' (1920) under Schmidt in the Atlantic when accurate evidence was obtained as to the breeding place of the European freshwater eels and lastly the '*Discovery*', now engaged in the South Seas investigating the conditions of life of whales under Kemp—these and many others have made the science of Oceanography what it is to-day.

The success which attended the '*Challenger*' and the later expeditions was so great that the 'wonders' of the sea were soon exhausted and it was feared that a period of stagnation was inevitable. Fortunately for science a school of Biologists arose who concentrated their attention on the study of the economic aspect of Marine Biology and on a clear analysis of the chemical and physical factors of the environment of marine organisms. The credit for giving this impetus belongs to the scientists of the North-West Europe who were then obsessed

with the idea, now proved largely illusory, of the dread of the depletion of the North Sea fishing grounds, due to employment of better and more efficient methods of fishing. A desire to co-ordinate their efforts gave birth to the famous international organization, Conseil International pour l'Exploration de la Mer.

Sea water, its suitability as medium.—The study of Marine Biology has in recent years taken two directions (1) the study of the Plankton and (2) the study of the animals of the sea-shore. Life in the sea and on land is fundamentally the same. Very similar natural laws in regard to origin, maintenance, growth, and distribution are operative in both cases. Perhaps, it may be said with some justification that life in the sea can be more easily understood than terrestrial life, because of the medium in which marine organisms live. Life, it is believed, originated in the sea, though Osborn (1918) and Macfarlane (1918) seem to take a different view. Sea water in recent years has been studied with a view to institute a comparison between its constituents and those of the blood of marine organisms. The body juices of marine organisms have been studied and the surprising fact has come to light that there is great similarity between sea water and the body fluids of these organisms, so that, it may be expected that marine organisms exhibit a comparatively simple form of relationship with the surrounding medium. Macallum (1926) has emphasized the essential similarity of composition of the liquid in the vascular system of many marine animals. The relative proportions of the elements sodium, potassium and calcium in the body fluids are very similar to those of the same elements in sea water.

Dakin (1908, 1912) has shown that the blood of such animals as the Elasmobranchs is in osmotic equilibrium with sea water and undergoes alteration with the changes in the surrounding medium.

There is a greater uniformity of temperature of the medium in which marine organisms live as compared with land forms which have to adapt themselves to fairly wide variations of temperature in their own bodies. Marine organisms are not put to this necessity to the same extent, as temperature variations in the sea are very much smaller and slower. It is probably because of sudden thermal variations on land that warm blooded animals seem to have had a terrestrial origin. Sea water has very nearly the same specific gravity as body protoplasm and the suitability of the former as the home for the latter has often been stressed.

It is this simplicity of relationship between marine organisms and the surrounding medium which has made possible such studies as artificial parthenogenesis, cleavage experiments, and control solutions. Land forms, if we accept the view that life originated in the sea, have had in their evolution to adapt themselves to conditions other than those to which they were originally

accustomed. In consequence, their relationship with their environment has become more complicated. In spite, however, of this initial attractiveness of marine problems, there is the great difficulty of carrying effectively investigations in the sea. On land, the Zoologist or Botanist marks out an area and makes an intensive study of the locality. He often gets results clear out and well-defined. In the sea the Marine Biologist meets with a shifting population subject to the control of a number of natural forces and in order to obtain correct information, free from error, investigations have to be carried on for several years, before a good understanding of the problems could be obtained. The whole water mass is in constant circulation and changes in one locality may have their effect felt in far off regions.

Plankton as the basis of Marine life.—In the sea, no less than on land, vegetable life is the basis of sustenance of all living things. This knowledge, which has now become so general, has been the result of several years of intensive study of the surface organisms which drift passively with the currents in the sea. The term Plankton was applied to these organisms by Hensen. That large numbers of organisms live in the sea had long been recognized. Spenser compared the numbers of the marine organisms to the stars in the sky and recent investigations have shown that the comparison is not far-fetched. The importance of the study of Plankton was felt to be so great that most of the Marine Biological Stations, as at Plymouth, Port Erin, Roscoff, Heligoland, and Naples in Europe and Woods Hole in America have had at one time or other experts on the subject attached to their staff. In recent years, extensive observations have been made on the east coast of Canada for the Canadian government and on the east coast of U.S., the work of Agassiz has been continued in the gulf of Maine. The German Plankton expedition of 1889 was fitted out to make an extensive study of Plankton and its distribution in the Atlantic and the results constitute a regular mine of information for research workers on Plankton.

Allen in his address, 'Food from the Sea', before the Plymouth Association in 1916, illustrating the great importance of Plankton studies, showed how the mackerel, an important food fish, is entirely dependent for its food on Copepods which themselves depend on Diatoms. The same idea occurs in 'Peridiniens, Copepoda, Sprats, Whiting, Cod, Man' in Johnstone's 'Life in the Sea' (1908). In tide water along the shore and in the sea surface there is a rich pasturage of Diatoms and algæ on which directly or indirectly marine animals feed. In this respect the Diatoms and the Copepods constitute almost the entire source of food supply of the marine organisms and when the further fact came to be recognized that the above-mentioned groups of organisms are of special relationship to fishes, a highly practical turn was given to Plankton problems

and the investigators of the last thirty years have been working out various aspects of the question. These investigations have taken three directions: 1. The study of the seasonal variation in the occurrence of Plankton organisms and the factors which are supposed to influence such variation. 2. The food value of Plankton. 3. A correct understanding of the life histories of the organisms which constitute such an important source of food and the life-histories of the forms of life (fishes especially), to which they afford sustenance. An intensive study of the occurrence of Plankton in the North Sea, the English Channel, and in the Irish Sea made it clear that there is a regular periodic cycle in the occurrence of the floating inhabitants of the sea. During the cold sunless winter there is practically no plant growth. In the English Channel and in the Irish Sea a burst of Diatom growth takes place in the early spring and again in the autumn. In the Gulf of Maine, on the coast of America, it takes place in March and again to a lesser extent in September. The organisms belong mostly to Phytoplankton, consisting of such Diatoms as *Biddulphia*, *Coscinodiscus*, *Rhizosolenia*, *Chaetoceras* and *Thalassiosira*. After persisting for a few weeks they gradually diminish, but only to be followed by countless swarms of Dinoflagellates. These disappear in autumn and their place is taken by Copepods. It is very significant that the time of Plankton maximum is also generally the time at which several pelagic fish-eggs are found in the open seas. In April, for instance, I noticed at Port Erin young plaice collected from the hatcheries of the station taken and liberated in the open sea where they were sure to find Plankton food in plenty.

Causes of Seasonal variation of Plankton.—Various explanations have been given in regard to these seasonal changes. It is well known that when the essential food substances are reduced to a minimum reproduction will almost stop and the numbers will fall off. As to the great increase itself, Raben (1910) has pointed out that it is due to the great accumulation of silicic acid in sea-water which makes possible the occurrence of Diatoms with their silicious skeleton in such countless numbers. When all the silicates have been extracted multiplication ceases. For the English Channel and the Baltic Sea a connection between the silicate contents in spring when the Diatoms are at the maximum and sometime afterwards when there is a fall has been noticed. Others have attributed the increase to temperature variations while Murray attributed it to increase of sunlight. The periodic seasonal occurrence of Phytoplankton has also been attributed to the varying amount of Hydrogen-Ion concentration (degree of acidity or alkalinity in the sea). Professor Moore (1915) working at Port Erin showed that the sea in the vicinity of the station is more alkaline in spring (April) than in July. There is then a slight increase in this alkalinity followed by rapid decline. Once more there is an

increase which rises to the maximum in March and April. There is here a close connection between these changes and the cyclic seasonal change in regard to Phytoplankton. It seems clear that during the winter there is an increase in Carbon-dioxide and this is used up gradually by crowds of Phytoplankton in early spring and alkalinity therefore goes up. The intensity of the photosynthetic process was well shown by Atkins (1926) who made an estimate of the annual production in the English Channel as about 1,400 metric tons weight of Phytoplankton per square kilometre.

Tropical Seas poor in Plankton.—A very interesting observation that has been made by several Plankton workers is the fact that the colder seas support a more abundant Plankton than tropical waters. Herdman mentions how in a few minutes' haul in the waters north of Norway he collected a mass of the large Copepod *Calanus finmarchicus* sufficient to be cooked and eaten by half a dozen of the boat's crew. Lohman in comparing the relative abundance of Plankton in the genial waters of the Mediterranean and the very much colder Baltic Sea thought that the latter contained a more abundant pelagic fauna. It is no doubt true that an hour's work with the tow-net in the Irish Sea is more fruitful than three hours' tow-netting in Madras, as I have myself experienced. The German Plankton expedition of 1889 showed conclusively that in the temperate North and South Atlantic more abundant catches were obtained than in the warmer waters of the intermediate seas. Lohman gives the density of Micro-Plankton organisms per litre as 20,000 at 50-40 Lat. N., 7,000 for 40-30 Lat. N., 1,800 for 30-20 Lat. N., 2,000 at 20-10 deg. Lat. N., and 3,000 at 10 Lat. N.

It is not, however, meant, that swarms of Plankton forms do not occur in the tropical seas. *Trichodesmium* has been known to cover large areas of the Indian Ocean and the South Atlantic giving rise to the appearance of 'saw dust'. The Red Sea owes its name to the red colour given to it by *T. erythraeum*. Hornell (1923) mentions crowds of flagellates in August bringing about great mortality among the fish of the Malabar Coast by asphyxiation. Extensive fish mortality among fish of the Japanese waters has been attributed to swarms of *Gonyaulax polygramma*. In Madras swarms of Salpæ occur in the months of September and October and swarms of the Terrellid *Loimia medusa* occur in the month of June. But it seems clear that, speaking generally, the tropical waters are much less rich in planktonic organisms. Several explanations have been given for this phenomenon.

Nitrates and Bacteria.—It is well known that Brandt attributed the paucity of Plankton in tropical waters to the greater activity of denitrifying bacteria. That such bacteria exist in the sea has been demonstrated by a host of workers—such as Baur (1903), Fertel (1903), Brandt (1898), Drew (1911) and others.

An observation in support of this view is the great scarcity of algal growth in shallow tropical waters as compared with that in temperate regions. At low tide, the sea front opposite the Port Erin Biological Station is one mass of sea-weeds. A further fact in this connection is the observation that when sewage and other nitrogenous waste is poured into the sea a free growth of sea weeds is found. The denitrifying bacteria keep down the nitrogen concentration to the minimum which has the effect of keeping down the Phytoplankton and this in its turn the Zooplankton. This view was fairly accepted at first but seems to have lost ground recently. Several investigators consider that denitrifying bacteria are not so common in the ocean as was supposed and it was also argued that on account of the vertical circulation in ocean waters any deficiency in the ocean nutrient salts would be made good. Atkins (1932) in a recent paper says, 'from the action of denitrifying bacteria in cultures rich in organic substances the deduction has been made that these bacteria will act similarly in a dilute inorganic solution such as the water which is supersaturated with oxygen and provides no source of energy for this process'. He points out that it is difficult to understand why bacteria should expend their own energy in taking oxygen from nitrates when there is plenty of the gas available in a dissolved condition in the seawater itself. He adds, 'furthermore the consumption of nitrate-nitrogen fixed by algæ and diatoms can be readily demonstrated, so that its absence in tropical waters can be looked upon as due to its complete absorption by the algæ in the well-illuminated upper regions'. It has also been thought that the increased metabolism of organisms in the tropics is the real cause of the rapid using up of the nutrient salts.

It should be mentioned in this connection that the seawater is saturated with nitrogen but the marine plants have not the power to take up nitrogen in the simple form though nitrogenous nutrients are necessary for building up of their protoplasm. These they take in the form of soluble nitrates. Large quantities of nitrates are carried down to the sea by the discharges of the rivers. This probably accounts for the increased abundance of plankton in such seas as the North Sea into which several large rivers empty themselves. Hornell (1923), for the Calicut coast, thinks that the swarms of flagellates which appear in August periodically are really due to the rapid multiplication rendered possible on account of the large quantities of nitrates and phosphates brought down by the rivers and poured into the sea during the monsoon.

Abundance of organisms may also be due to the upwelling of waters from below carrying with them from the depths untapped sources of nutrient salts. Rapid production of Phytoplankton reduces the supply of nitrates in water. Ammonia which is formed as a result of the breaking down by

bacteria of the bodies of dead organisms, has to be changed into nitrites and nitrates by oxidation and combination with bases before being rendered available for animals as food. This change is brought about by the bacteria of the class of 'Nitrifiers' which, judging from experimental evidence, seem to be prolific near the shore and near the bottom but not to any appreciable extent in the open sea. It has been further surmised that the chief area of production of nitrates by bacterial activity coincides with the area of regeneration of phosphates in shallow marginal seas. There is also Prof. Moore's view (1920) according to which the source of nitrogen is the atmospheric elemental nitrogen dissolved in sea water and not ammonia, nitrates or nitrites. There is the further question of the action of Bacteriophage on ocean bacteria. To what extent the former control the action of the latter is largely a matter of speculation.

Our knowledge of the metabolism of the sea is not complete and further investigations alone can clear up much that is not fully understood.

Other Salts in the Sea.—Besides the nutrient salts present in the sea water there are other salts such as those of calcium, silicon, and strontium which are of great importance to many organisms. These salts are withdrawn to form the skeleton of such groups of animals as the Diatoms, Sponges, Corals, Molluscs, and Echinoderms. There is a constant interchange, the substances being first withdrawn and built into the skeleton and then once again returned to the water with the death and decay of the organisms. It is a curious fact that in the tropics massive calcareous skeletons are built up while in the colder regions skeletons of a silicious nature are generally the rule. As an explanation, it has been stated that the high temperature of the tropical waters favour the secretion of calcium carbonate. But why it should be so is not yet clearly understood.

Tropical waters richer in species.—Another interesting difference between tropical Plankton and that of the Arctic and Antarctic Seas is that the former is rich in species while the latter is rich in individuals. An explanation offered is that in the colder waters bacterial and enzyme action is slow and consequently vital activities are correspondingly reduced, so that organisms generally live longer. A catch in the cold-north often represents several generations of individuals, while in the tropics, due to the more rapid action of enzymes and bacteria, metabolism is more active so that organisms grow, reproduce, and perish more quickly.

Economic aspect of Plankton.—The importance of Plankton in the economy of the sea cannot be over-estimated. When about 30 years ago the value of Plankton as affording food to the larger forms of marine life, particularly fish, came to be realized, Plankton study received a fillip and led to an intensive investigation of the Plankton and its distribution in European

and American waters. As was to be expected earlier studies were entirely qualitative but this stage was soon passed and attention was directed by the Kiel school of Planktologists to a quantitative study of the organisms in the sea.

Herdman in his 'Founders of Oceanography' (1923) refers to their work in the following words: 'From certain samples obtained in the West Baltic it was calculated that every square mile contained 80 to 100 billions of Copepoda and from the relative proportions of eggs, larvæ, and adults it was deduced that for the sixteen miles of a certain Fishery district the annual consumption of Copepods must be 15,600 billions and that consequently that locality supports Copepod food sufficient for 534 million herrings of an average weight of 60 grams'. From catches of floating eggs and embryos the planktologists came to the conclusion that, taking six of the most abundant fish as the cod and some flat-fishes, the eggs present were probably produced by about 1,200 million spawners which led them to the further conclusion that the total population of the North Sea in the year 1895 amounted to 10,000 millions. Other calculations led them to the view that the total catch of fish for the year amounted to one-fourth the total population.

The work of the Kiel planktologists was based on the assumption of a uniform distribution of Plankton in the sea. Herdman in his reports setting forth his investigations on the Plankton of the Irish Sea, has conclusively shown the fallacy of such a Plankton distribution and the error of basing such colossal calculations on unproved data. The following table shows the result of simultaneous catches made by Herdman from either side of a boat and clearly proves that the assumption was not justified.

April 13th, 1907, Surface	Net A. 16 cc	Net B. 15 cc
Balanus nauplii ..	3,000	None
Copepoda nauplii ..	7,000	2,000
Copepoda ..	13,000	None
Coscinodiscus ..	8,000	14,000
Biddulphia ..	40,000	70,000
Rhizosolenia ..	1,000	3,000
Thalassiosira ..	2,000	7,000
Chaetoceras ..	None	1,000
Oikopleura ..	2,000	150

(From Herdman's 'Founders of Oceanography'.)

I have gone out tow-netting in the Irish Sea, Mediterranean, and in the Bay of Bengal and nothing has struck me more

forcibly than the almost erratic way in which the Plankton organisms seem to turn up and the conclusion that I have come to is that they occur more in patches or groups than in a uniform manner. I have obtained catches in particular areas consisting almost entirely of Copepods, while 500 yards off the net has brought up other forms of life.

In this connection it may be stated that Johnstone (1908) reproduces Cleve's chart of the distribution of the Plankton of the North Sea from which it is seen that for the year 1897 the North Sea contained at least five different types of Plankton; 'Tripos' in the centre; 'Halosphaera' forming a belt from Denmark to Scotland; 'Coscinodiscus' almost coastal on either side; while 'Tircho' and 'Sira' Plankton occur bordering south of Norway.

Plankton not enough.—As against Hensen and his school who probably over-emphasized the importance of Plankton as food for marine organisms, Pütter (1911) of the University of Bonn held that the Plankton available in the sea is much too insufficient for the requirements of Plankton-feeding animals, and suggested that an enormous quantity of food exists in the sea in the form of dissolved compounds in water. He calculated the amount of carbon required by animals of known weight from their oxygen consumption in a given time. He found that to obtain the required amount of carbon from Plankton an impossible quantity of water had to be strained. He therefore concluded that animals could not obtain their food from the Plankton. He found on the other hand that the sea water contains a sufficiency of organic carbon compounds to supply the demand.

Subsequent investigators like Henze (1909), Raben (1910), and Moore (1912), as quoted by Herdman (1923), have come to conclusions showing that the amount of organic carbon in solution is not anywhere near the amount considered to be present by Pütter.

Dakin (1925), as a result of his investigations, is not prepared to admit the correctness of Pütter's conclusions. We are therefore forced to fall back on the well-established opinion that the mainstay of many of the marine fishes are the Diatoms and the Copepods.

EFFECT OF TEMPERATURE, SALINITY, AND LIGHT ON MARINE ANIMALS.

Temperature.—Plankton animals are in intimate relationship with the sea water that they inhabit and there is no doubt that the chemical and physical condition of the surrounding medium is of paramount importance in their life. Recently a considerable amount of work has been done to investigate the effect of temperature, salinity, and light and of other factors

on marine animals. That temperature exerts a profound influence on animals has long been known. The rate of metabolism becomes enhanced with increase of temperature. It has been shown that in a number of cold-blooded animals such as *Amphioxus lanceolatus*, and *Beroe ovata*, as quoted by Harvey (1928), there is an increased rate of oxygen absorption and a corresponding output of CO_2 with increase in temperature and numerous experiments have shown that a rise of 1°C ., increases the rate of metabolism by 10% . Thus, there would be a doubling of the rate of absorption for a rise of 10°C . It is generally admitted that tropical and subtropical animals have a high rate of metabolism. If we, as we must, concede this, then it is clear that these animals would require a larger amount of food than those living in higher latitudes. Possibly this may offer an explanation as to why in the tropical waters Planktonic organisms are never so abundant as in the colder regions. We have here, probably, the real cause of the observed facts of the animals inhabiting the colder regions attaining to a much larger size than similar animals in the tropics. Higher metabolism always carries with it greater destruction of body tissues with the resultant loss in the power of growth.

Not only the general metabolism but also other life phenomena such as locomotion, ciliary action, growth, and breeding are influenced by increase of temperature. Harvey (1928) quotes an interesting experiment by Hogben in which the latter subjected the excised heart of *Maia squinado* to varying temperatures and found that at 4°C . it practically stopped working and at 21°C . it was apparently too much injured to function. Between the two extremes the rate and amplitude of the beat increased with temperature. Orton (1920) as the result of growth experiments on *Sycon coronatum* and *Grantia compressa* came to the conclusion that these animals grow to a larger size in winter but do not begin to breed until April or May. Individuals born in summer, however, rapidly attain maturity even when they are very tiny. He also shows that in the case of *Ostrea edulis* breeding begins earlier (as in the mackerel) in the more southern and warmer regions and later in the colder-north. It appears to commence breeding at about $15\text{--}16^\circ\text{C}$. in varying salinities and continues to breed so long as the temperature remains above this figure, so that in warmer situations there is a longer breeding season than in the colder. In regard to the mackerel, *Scomber scomber*, it is now clear that it breeds throughout its range between temperatures $12\text{--}13^\circ\text{C}$. Consequently spawning of this fish begins earlier in the southern regions of its range. The lobster seems to require one temperature for breeding and another for optimum growth. Russel (1932) has carried out extensive investigations on the breeding and growth of *Sagitta elegans* in the Plymouth area where it is a common planktonic form. A study of this form reveals

the fact that it produces possibly five broods. An examination of the adults of the various broods brought out the interesting fact that the different broods differ markedly in regard to their size.

May 1930 brood attained a size of	19½-20 mm.
June " " " "	13½-14½ mm.
July " " " "	13 mm.
September 1930 brood attained a size of	10-10½ mm.
February 1931 " " " "	12-12½ mm.
April-May " " " "	16 mm.

Side by side with this difference there is also the variation in the size at which the different broods matured, the broods with the smallest size adults maturing at a smaller size. Another fact is that the time taken to reach maturity in colder months was longer than in the warmer. Thus individuals born in February took 94 days. Those born in July 43 days, and those born in September did not mature till February next, i.e. nearly 165 days. This shows clearly that in the longest lived individuals gonad development was deferred. A very curious case of the influence of temperature on reproduction is recorded by Michael (1916). He observed that in *Salpa democratica*, as the temperature of water increases between 15-20°C., the zooids of sexual reproduction decrease at the surface while those of asexual reproduction increase. Gray's experiments (1928) have shown that in the case of trout's eggs, when they are incubated at low temperatures, the embryos at the moment of hatching are larger than those hatched from eggs which have been incubated at higher temperatures. Increase in temperature of incubation raises the growth-rate of embryos, but at the end of the larval life the full embryo is smaller than after a slower development at lower temperatures.

Cutler (1916) experimenting with plaice and flounders and using 'cold' and 'hot' tanks at the Plymouth Laboratory came to the conclusion that in the formation of the rings of growth in scales, temperature, rather than food, was the deciding factor. [Unfortunately opinion here is not unanimous. Gray and Setna (1931) working on *Salmo fario* have come to the conclusion that the food available is the deciding factor.] From calculations of amount of fat in the sprats and flounders in Norwegian waters it has been concluded that temperature has a profound effect on metabolism. It is said that the European eel breeds at depths of 500 fathoms and at a temperature of 7°C. in the required depth. It is now admitted on all hands that temperature variations greatly influence marine organisms not only in regard to their metabolism but also in regard to their growth and reproduction. Lo Bianco's contribution (1899) on this subject gives instances in support of this. It is clear from what has been said that temperature must necessarily exert a

very important influence on the ^{*}geographical distribution of animals. The distribution of coral reefs is almost entirely determined by temperature as these are found in tropical seas only. In regard to the reproduction of animals living in the stenothermal waters of the tropics Semper (1883) was of opinion that the annual temperature variations are so small that the reproductive activity is not affected and that most tropical animals breed throughout the year. This may be so, but investigations with tropical animals have not been attempted to the same extent as for the animals of the colder seas and extensive observations are required before a general statement on the subject can be made.

Sunlight.—That sunlight exerts a marked effect on organisms in the sea is now well known. The great burst of Diatom life after winter in early spring is almost entirely due to the increased solar energy. That there is no such clear cut Plankton activity in the tropics, as for instance in the Madras coast, is probably due to availability of abundance of sunlight throughout the year. Very often the presence or otherwise of the requisite quantity of sunlight in a particular part of the year in a definite area of the sea, may have important bearing on valuable fisheries. It is now clearly established that the mackerel first feeds on Phytoplankton, then on Copepods, then selectively on general Zooplankton. The Copepods which form their principal food themselves depend on Diatoms which depend for their growth on the amount of sunlight available in February and March in the British seas. Thus any failure or delay in this respect in these two months will correspondingly be felt in the May mackerel fishing. Bullen (1909) showed in his 'Plankton studies in relation to the western Mackerel fishery' the existence of a correlation between the catches of mackerel in May and the amount of Copepod Plankton available. Allen (1907), in his interesting paper 'Mackerel and Sunshine', has shown that there is a direct correlation between the amount of sunlight available in February and March and the mackerel catches in May.

Vertical migration.—It is known that different marine organisms react towards light differently. It is a matter of common observation that of the many Plankton forms kept in a jar of water several crowd towards the illuminated window side while others keep away from that side. It is within the experience of all who have gone out night tow-netting that catches are generally more abundant in the night than in the day. Esterly (1919) working in the San Diego region shows this to be the case for several species of Copepods. Russel (1926) in a series of papers dealing with the vertical distribution of Plankton based on material collected by using horizontal nets at fixed depths has conclusively shown that the different species of fish differ markedly in regard to the depths at which on a sunny day their larvæ are found. He has also called

attention to the variation of this depth in accordance with the variation of the intensity of light.

The works of Russel (1923-28), Michael (1916), Esterly (1919) and those of others have also shown that many Plankton forms exhibit the phenomenon of vertical migration. The cause, however, is not equally obvious. It is possible, as has been suggested by many, that organisms change their geotropic reactions in accordance with changes in the light intensity.

Vertical diurnal migration of organisms has also been attributed by Ostwald (1902) to variations in the viscosity of water induced by changes of temperature. It is here forgotten that organisms are *living* things and cannot be expected to behave like floating objects. Michael (1916) basing his observations on *Sagitta* and other organisms states that different forms sink differently and that, therefore, there is a specificity in sinking and consequently viscosity cannot be an explanation. Others have attributed this migration to a physiological or metabolic rhythm.

Salinity.—Salinity is another factor which influences marine life, but probably not to the same extent as temperature. In the open ocean, conditions are usually normal (35 parts in 1000) and salinity variations are not very pronounced. In special parts of the ocean as the Sargasso Sea the salinity may be up to 38 parts and in such enclosed seas as the Mediterranean and the Red Sea it may be even higher. Near the coast great changes, due to fresh water inundations, are often experienced. It is probably this peculiar feature that has made coastal forms adapt themselves to wide ranges of salinity, when such changes, are not too sudden. I have noticed that *Morphysa gravelyni*—a typical brackish water form—is able to live fully submerged in fresh water but is not able to reproduce. It may be, as has been shown recently by Reid (1930), that the influence of fresh or salt water is not fully felt by such animals as they bury themselves in the sand in so far as their ordinary life processes are concerned. Pantin (1931) has shown how *Gunda ulvæ* is able to withstand change from complete fresh to undiluted sea water. Many sea fishes move regularly into fresh water and *vice versa*, and the Cambridge Zoological survey of the Suez Canal has shown that several species of fish of the Indian Ocean live in the Great Bitter Lake. In this respect it is interesting to note that Dakin (1908) has shown that the blood of several fishes and several Invertebrates is almost of the same osmotic pressure as that of the water in which they live and many of them could rapidly adjust themselves to salinity alterations. It is probably for this reason that coastal animals are favourites in aquaria because of their capacity to bear salinity variations easily. Many of the marine animals however are unable to withstand more than small changes in salinity of the sea water. When dilution takes place and osmotic pressure is reduced they

gain in weight by the inflow of water and usually death results. Other animals are more or less able to keep the osmotic pressure of their body fluids higher than that of the surrounding medium undergoing dilution. The work of Schleiper (1929) and Beadle (1931) has shown that those animals which are able to keep their osmotic pressure higher probably do so by greater respiratory activity.

Whether variations in salinity influence breeding has been the subject of much experimentation. The prevailing view seems to be that *normal* changes of salinity have little or no influence on breeding.

Indian Plankton.—Our knowledge of the Plankton of the Bay of Bengal is almost entirely due to the work of Sewell (1912, 1913, 1926, 1929a, 1929b, 1932), on the material collected by R.I.M.S. *Investigator*. Other collections in the neighbouring waters have also been made by Herdman and Gardiner, Cleve and others. Sewell's publications dealing with the Copepods have thrown considerable light on the occurrence and variation of these important Planktonic organisms. Regarding the seasonal variation of Plankton Sewell says that it decidedly increases from early November to the beginning of January and then again diminishes, only to rise again in March and April. Speaking in particular of Copepods and basing his observations on his work in the Tavoy Basin he came to the conclusion that the number of Copepods frequenting the surface waters bears a close relationship to the state of the tide, tow-netting taken at or near low water showing a marked superiority as regards the number of Copepods present over one taken at or near high water, and as an explanation for this he thinks it might be due to vertical movement, the Copepods sinking below the surface at the time of the high tide and rising again when it is low tide. Sewell attributes this vertical movement to change in the density of sea-water at different states of the tide. In addition to this, he made the general observation that the number of Copepods frequenting the surface showed very considerable variations from day to day as also did the total surface Plankton.

A certain amount of work has also been done on the Madras coast by Menon (1931) and on the Malabar coast by Hornell and Naidu (1923). There is the same burst of Diatom growth followed by a rapid increase in their numbers both in Malabar and in Madras. As in Europe the diatom increase has been noticed to be the forerunner for the Copepod maximum. It must, however, be pointed out that for Madras the Diatom rise is not by any means sharp, as for the English Channel, and the Irish Sea and this is probably due to the fact that there is at this latitude no month in which sunlight is not available. Further, the Diatom growth is not nearly so marked as in the European countries. This must necessarily be attributed to a number of causes, bacterial and otherwise.

It is interesting to note that the Phytoplankton period which is very circumscribed in European waters is more extended in Tropical Madras. This is probably due to the availability of enough sunlight for the Plankton growth throughout the cold months.

Shore problems.—I must now turn to a brief consideration of the problems of the shore and in the limited time at my disposal I can but merely refer to some of the most important factors which influence organisms of the seashore. The intertidal zone is one of great stress and strain. In a country like England this zone is very extensive and amounts to 620,000 acres. Alterations of temperature, salinity and light will exert a profound influence on the organisms in this region. Sand itself is an important factor in the beach environment and there is a close relationship with such phenomena as capillarity and evaporation processes which have the closest relation to littoral life. The shore sand, though apparently alike, is not without important differences. There is difference in grain size, or a difference in grade as it has been called. 'Grade' will naturally determine the water retention and absorption capacity as well as the capillary lifting powers and the porosity to water and gases. Submergence or exposure experienced by any point will be defined by its position relative to the mean levels of high and low water. It is obvious that conditions to which those at the high water level will have to adapt themselves will be different from those to which the organisms at the low water level will be subjected to. The periodic inundations due to the incoming tide introduce changes in temperature. As a result of temperature readings in the intertidal zone in Port Erin beach, Bruce (1928) came to the conclusion that there is considerable difference.

He gives the following readings :—

Depth CM.	0	5	10	15	20
Temp. C.	18·8°	17·6°	16·5°	15·6°	15·3°

Such temperature variations cannot but influence the numerous organisms such as Molluscs, Annelids, and Echinoderms which live in the subsoil.

Salinity is a factor in the life of the organisms of the seashore. Other things being equal, the interstitial waters of the beach may be expected to be isohaline with those of the adjacent sea. This would be so if there were no disturbing factors. The presence of superficial streams or subsoil streams will naturally result in a reduction of salinity. Often, as a result of difference in the admixture of fresh water even in a level beach, isolated areas of low salinity may occur and this fact has been associated by Bruce (1925) with the remarkable distribution of certain sand-living Dinoflagellates in the Port Erin Bay.

In addition to the physical factors mentioned the vast assemblage of plants and animals of the seashore introduces a biological factor of no small importance. The gases evolved in respiration and carbon assimilation, the addition to the sand of waste products of digestive activities, the variation in the Hydrogen-Ion concentration and the by-products of bacterial activity introduce factors of a biological nature which together with the physical factors make the problem of life in the seashore very complex indeed. In recent years such problems have been to the fore in England and workers like Bruce (1924, 28), Stephen (1931) and others have been investigating problems of this kind in special parts of the English Coast. Another direction in which Marine Biological Research has been continued is the study of the marine animals in associations. Work of this kind was first started in the Danish waters and the extensive use of the bottom sampler enabled Peterson (1913) to advance the opinion that, as a rule, it is best to regard animals living in the sea bottom as communities just as Botanists group together the vegetation of the land into plant communities. Work of this kind has been taken up for the English Coast in the Plymouth area and gives promise of interesting results (Ford 1923).

Need for Marine Biological work in India.—Compared to what has been done in other countries in the field of Marine Biology a great deal remains to be done in Indian waters. We are greatly in the dark as to the life histories of many of our important Plankton feeding fishes. We know very little about their movements, with rare exceptions. We do not know much in regard to the Plankton on which they feed during their larval and post-larval periods and are also equally in the dark as regards the life histories of the Planktonic organisms themselves. Studies of this nature have been carried out in the Marine Biological laboratories of the world. It may be argued by some that the work may be left to the Fishery Departments of the country. I do not agree with this view. No doubt these departments will take their due share in these investigations. They will have their special problems awaiting solution. In no subject more than in Marine Biology is co-operation more needed. Marine Biological Science in Europe would not have been what it is now but for the co-operation of all concerned.

More and more attention is being paid in Europe to the study of the life histories and the habits of various animals. I may mention in this connection the enormous amount of work done on the food and habits of the teleostean larvæ and adult fishes by Hefford (1909), and Lebour (1919) at Plymouth. The life history of *Calanus finmarchicus* worked out by Lebour and that of *Oithona nana* by Helen (1923) are notable instances.

Necessity of an All-India Biological Station.—For work of this kind Biological Stations are necessary. India has a long

coast line and conditions of temperature, currents, and salinity vary in different parts. There are only three places in India in which work of this kind could be carried out, viz. Bombay, Karachi, and Madras. No doubt such studies will receive due attention at the hands of the professors and research students attached to the Colleges and Research Laboratories of these places. Prof. Mathai has already done much to popularize Marine Biology by his work at Karachi. In addition, it is necessary that there should be an All-India Marine Biological Station. In trying to evaluate the claims of the various places for the location of such a station, it seems to me, that the only place which will satisfy all or nearly all the conditions which such a station should possess, is Pamban or Mandapam at the southern extremity of the Indian continent. It possesses the most important condition, that of a good climate. It is suitable for work all the year round. The sea water in this region is entirely free from any admixture of sewage water. There are no great rivers discharging large quantities of fresh water thus bringing about annual destruction of millions of inhabitants of the sea. It is the meeting place of strong currents and the free interchange results in a thorough oxygenation of the waters. The sea coast is very shallow, so much so, that at low tide extensive stretches of the sea are left uncovered making possible collection of large numbers of burrowing animals. Dredging and tow-netting have been attempted and it is known that the surface and the sea bottom here support a fauna no less rich than the Bay of Naples. The station, if one is established, should be an All-India one, run on the lines of the All-England Biological Station at Plymouth. We should have on its staff competent Biologists who will be experts in the various branches of Marine Biological study. Every University in India should be approached to support a table at the Research Station to be occupied by students from the respective Universities. There should be vacation courses on special lines of Marine Biological work and these should be arranged at times convenient to the various Universities. It is indeed strange that the only important country which lacks a first class Biological Station of this kind is India. Recently Cyril Crossland has established a Biological Station for Egypt at Chardaga in the Red Sea. I do not owe an apology for putting forward a scheme of this kind at a time when there is financial stringency in the country. The scheme will take time before it matures, but the idea will have to become fully familiar before it becomes a real fact. The Madras Fisheries Department is supporting a small station in the island of Krusadi, very near Pamban. This was the direct outcome of a discussion held some years ago under the auspices of this section of the Congress. The fauna of the region is being worked out and the results are being made available in the *Bulletins* of the Madras Government Museum by the tireless activity

of Dr. Gravelly. The importance of a Marine Biological Station is so great and the benefits which are likely to accrue to the country in the long run so numerous that only a Station on an All-India basis would meet the situation. When I had almost finished the preparation of this address I was very glad to notice in the columns of the *Current Science* a communication from Dr. Setna of Bombay urging the establishment of a Biological Station for India and emphasizing the claims of Bombay, as a suitable place for the location of such a station. I am entirely one with him in his desire for the starting of an All-India Biological Station but I am very doubtful about the suitability of Bombay in this connection. The successful working of a Biological Station depends on the availability of absolutely clean sea-water. Proximity to large industrial centres is a decided disadvantage as there is bound to be sewage influx into the sea. A library, the necessary adjunct to a Biological Station, can be built up slowly; Port Erin, Plymouth, Naples, and Heligoland have all their splendid libraries. It is not necessary that such a Biological Station should be under the shadow of a University.

It is not intended that at this station only applied Marine Biological work should be carried on. The economical aspect no doubt should always be kept in view. But during the first few years it is more than probable that pure research will be the primary object and the 'loaves and fishes' problems secondary. Work at first must necessarily be faunistic. The Biological Station at Naples—the greatest station of its kind—recognized the importance of this aspect of work by issuing its famous *Fauna und Flora des Golfes von Neapel*. A knowledge of the environment is as indispensable to a complete understanding of marine organisms as that of the organisms themselves and the second step therefore would be ecological and then would come the more intensive studies of structure and function. These are the necessary steps through which work of this kind must pass. It is not wisdom to condemn pure research. Sir Stanley Gardiner in his address before the British Association for the Advancement of Science (1920) closed his address with the following words: 'There is no knowledge of which it is possible to answer the question, "what is the use of it?" for only time can disclose what are the full bearings of any piece of knowledge. Let us not starve pure research because we do not see its immediate application.' The path of economical research has undoubtedly very great attractions. Pure research is even harder and must be viewed with sympathy and understanding.

Gentlemen, I have finished and I thank you most sincerely for the very great courtesy you have shown me in listening to my address.

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Section of Zoology.

Abstracts.

1. Multiplication of Trichomonads by multiple longitudinal splitting or fission.

G. C. CHATTERJEE and A. N. MITRA, Calcutta.

In three previous papers, we have shown that instead of the binary method of division (a trichomonad dividing into two equal halves, each one having all the organelles of the one dividing), which is described as the method of multiplication in all papers on the subject, there is another method of multiplication, in which an adult organism gives origin to numerous minute amoeboid organisms having no flagella, which subsequently develop their organelles. We have since found another method of multiplication which is the subject of this paper, in which an organism possessing all the organelles but very small in size, splits up into innumerable organisms which possess a single flagellum, which develops later on into an ordinary trichomonad. The different stages in the development have been observed from minute ones being not more than 2 or 3 μ to 18 or 20 μ or more.

2. Myxosporidia from India.

H. N. RAY, Calcutta.

Several myxosporidia have been studied from fish, amphibia, and reptile. Following genera are for the first time recorded from India: *Ceratomyxa*, *Chloromyxum*, and *Zschokkella*.

Life cycle of *Chloromyxum amphipnoui* n. sp., and *Zschokkella prashadi* n. sp., have been dealt with in detail. Fish mortality in a confined area of water due to myxosporidian infection has also been discussed.

3. *Lankesteria culicis* from *Aedes (Stegomaya) albopictus* in Calcutta.

H. N. RAY, Calcutta.

Historical review of the distribution of *L. culicis* is given. Its life history revised and certain features, such as method of association, chromosome number, and the position of the residual mass in the spore have been found to be worth recording. Occurrence of epimerite has also been discussed.

4. Boring apparatus in *Balantidium*.

H. N. RAY and M. CHAKRAVARTY, Calcutta.

Presence of a boring mechanism in several species of *Balantidium* have been noted. It is suggested that human *Balantidium* may be investigated upon from this point of view.

5. On the trematode found in the liver of *Ophiocephalus striatus*.

T. SUBBRAMANYAPILLAI, Bangalore.

The anatomical and embryological study of this trematode seems to suggest that it is a form more allied to *Fasciola hepatica* than to any other

trematode. It agrees with the latter species in all respects except in the position of the genital aperture as well as in the disposition of the gonads. The genital opening is far behind the ventral sucker, almost in the middle of the ventral side. The testes are centrally placed, one behind the other, the anterior one lying just behind the genital opening; and the ovary lies between the two testes. These differences can be reconciled with the conditions existing in *F. hepatica*, if the disposition of the gonads in the pre-adult stage of the parasite, under consideration, is studied. There are indications in this, to show, that the genital aperture was once anteriorly placed in front of the ventral sucker, and that it has shifted back correlated with the need for a greater efficiency of the ventral sucker. This upsets the normal position of the testes, and resulted in a torsion which brought the once right testis to the centre, and the once left testis more forward, and then to the centre, in front of the ovary.

If Biogenetic law can be relied upon, the above facts show that the two trematodes arose from a common ancestral form, whose permanent host was a fish and the intermediate host a water-snail. The ancestral cercaræ must have evolved along two lines, one showing a tendency for securing a terrestrial vertebrate host; the one that remained in a Piscian host became more specialised and diverged from the ancestral form, whereas the other kept up much of its ancestral traits.

6. On a new trematode of the genus *Astiotrema* Looss, 1900, from the intestine of a tortoise, *Chitra Indica*.

G. S. THAPAR, Lucknow.

The genus *Astiotrema* was erected by Looss in 1900 for the reception of two species, *Distomum reniferum* and *Asia Impleta*. Subsequently several other species have been added to the genus. The present paper adds another species, *Astiotrema indica* n. sp., to the genus in question.

The specimens were obtained from the intestine of *Chitra Indica* from the river Gomti and present the following characters :—

1. Spherical ovary in front of the testes.
2. The testes are lobed 9-10 lobes in each.
3. Receptaculum seminis is large, semilunar in shape, transversely disposed across the body.
4. The cirrus is very characteristic and forms a definite coil in its course.

A detailed account of the anatomy of the trematode is given. The paper concludes with discussion on the status of the subfamily Astiotremiæ Baer, 1924, and in the light of the recent researches, gives an amended definition of this subfamily.

7. On the morphology of *Discocotyle sagittatum*.

G. S. THAPAR and M. B. LAL, Lucknow.

In the course of his investigations on the helminth parasites of fishes that died in the aquarium of the London Zoological Society, the senior author found a very heavy infection in the gills of salmon trouts by these parasites. The excretory system was there examined in fresh specimens and the other details in the anatomy are now studied by both of us from a series of prepared slides.

The genus *Discocotyle* has been studied by several earlier workers but the following interesting features are now being recorded :—

1. The division of the body into three regions—the large middle region being the sexual region of the animal.
2. The branched diverticula of the intestine.
3. The peculiarities and details in the excretory system appearing to connect Monogenea and Digenea together.

4. The peculiar anchoring process at one end of the egg.

A detailed account of the anatomy, particularly of the excretory and reproductive systems, is given in the paper.

8. On the morphology of a new trematode from Golden orfe.

G. S. THAPAR and J. DAYAL, Lucknow.

A large number of trematodes were collected from the intestine of Golden orfe and they present the following distinguishing characters:—

1. Presence of armed genital sucker anterior to the acetabulum.
2. Diagonal and lobed testes.
3. The lobed ovary in between the two testes.
4. Coiled uterus lying between the acetabulum and the posterior testes.

A detailed account of the anatomy of the animal is given. The paper concludes with a discussion on the systematic position of the animal. It appears to be closely allied to the genus *Sphaerostoma*, but differs from it in several important features which necessitate the creation of a new genus for the present form.

9. On the morphology and systematic position of *Cephalogonimus* and *magnus* n. sp. from *Trionyx gangeticus*.

B. B. SINHA, Lucknow.

A large number of specimens were obtained from the intestine of *Trionyx gangeticus* at Lucknow. The chief peculiarities are:—

1. Anterior half of the body is covered over with spines.
2. Oesophagus is as big as the muscular pharynx.
3. The excretory vesicle is longer than the arms of 'Y'.
4. The uterus completely fills the posterior part of the body and can be distinguished into ascending and descending rami.
5. The yolk-glands are in the middle third of the body, extending beyond the posterior margin of the acetabulum.
6. An elongated, flask-shaped cirrus-sac with a long, narrow neck is present.

The new species differs from other members of the genus in its larger size and in the extent of the vitellaria.

The paper concludes with a discussion on the systematic position of *Prosthogonimus*—which has recently been included in the family Lepodermatidae by Poche (1925). The author has argued for the exclusion of *Prosthogonimus* from the family Lepodermatidae and has advanced his arguments in favour of its inclusion under the family Cephalogonimidae along with the genus *Cephalogonimus*.

10. Notes on the occurrence and external features of a fresh-water poly-chæte.

C. BAL, Benares.

A poly-chæte worm was found swimming freely in river Ganges close to the Ghats at Benares.

Two species of poly-chæte *Matla bengalensis* Stephenson (1908, 1910) and *Spio bengalensis* Willey (1908) have been recorded previously from Port Canning (Gangetic Delta), but none so far was found to occur up the river beyond this. The occurrence of a poly-chæte about 500 miles up the stream from the delta is noteworthy.

The question of the distribution of poly-chætes in fresh and brackish water has been briefly discussed.

Only one specimen of this species could be collected and the anterior region was unfortunately mutilated. It could not, therefore, be identified. An attempt, however, is being made to collect more specimens of this species.

The structure of parapodium and various types of Setæ has been given. The worm possesses branchiæ.

11. An account of the development of *Diapatra variabilis* (Southern).

G. KRISHNAN, Madras.

The development from the atrochal stage to a period when most of the adult structures have been formed, is described. The larvæ were reared in the laboratory. The fertilized eggs occur in masses inside the tubes of the parents. They are heavily yolked, and the larval history is much abbreviated. There is no free swimming phase, and the early development takes place inside the tube, the young leaving it with several pairs of parapodia. The tentacles, anal cirri, the jaws, and the branchiæ appear comparatively early before the worm develops about 10 to 11 parapodia. The cilia are reduced. The true compound setæ are absent. The sequence of appearance of setæ is described. The tube-forming habits are also described. A comparison is made with the development of *Diapatra cuprea*.

12. On the physiological significance of the enteronephric type of nephridial system found in Indian earthworms.

K. N. BAHL, Lucknow.

During the years 1919-1926, the author described the 'enteronephric' type of nephridial system in earthworms belonging to the genera—*Pheretima*, *Lampito*, and *Woodwardia*. In all these genera, the nephridia discharge their excretion into the intestine instead of one to the surface of the body. It was further suggested that the basis of classification of nephridia should be the place of their opening rather than their size; Stephenson in his recent monograph on the Oligochæta has accepted this suggestion and classified the nephridia into 'exonephric' and 'enteronephric' types.

The question of the physiological significance of these 'enteronephric' nephridia still remains open although it was suggested in 1919 that the enteronephric system was possibly an adaptation for the conservation of moisture in a dry climate. In the present paper, the author has compared the habits of *Pheretima* with those of *Eutyphæus*, the former possessing enteronephria and the latter exonephridia. He has, next, compared the castings of these two worms in respect of their shape and consistency, which go to prove that his suggestion is correct. Finally, he has given data with regard to the percentages of moisture present in the castings of these two kinds of worms. In all the five experiments made, the percentage moisture was higher in the castings of *Eutyphæus* than in those of *Pheretima* proving conclusively that the gut of *Pheretima* absorbs the water from the excretory fluid and conserves it for the needs of the worm.

13. The larval stages of *Acetes* sp.

M. KRISHNA MENON, Madras.

A fairly complete account of the larval development from the earliest free-swimming stage up to one in which the animal, in all essential respects, has acquired the adult characters is given. In all nine stages have been

studied. There are three protozoa and two mysis stages. The development of the full number of pleopods is an extremely slow process. The development shows many interesting features of resemblance to the developments of *Sergestis*, *Petalidium*, and *Lucifer* of the same family.

14. Distinctive characters of the larval development of *Callianassa* sp.

M. KRISHNA MENON, Madras.

The development of this species of *Callianassa* differs considerably from those of all other species of the genus so far studied. One of the most important differences is the abbreviation of larval life, there being only two stages. The mouth appendages, abdominal somites, and telson of these show important variation from those of the corresponding stages of other species of *Callianassa*. On the other hand, in the shortness of larval life, in the nature of the telson, and in the absence of uropods during this period this form resembles the development of the genus *Axiis*.

15. The larval development of *Gebiopsis* sp.

M. KRISHNA MENON, Madras.

There are five larval stages in the development of this species whereas most of the other species of *Upogebinae*, the developments of which have been studied, pass through only four stages, and in some cases only three. The present form differs from the others in several other important respects also, as for instance, in the presence of lateral spines in the abdomen, and in the very late appearance of the median spine in the posterior edge of the telson.

16. Development and habits of *Hippa asiatica*.

M. KRISHNA MENON, Madras.

Larvæ of *Hippa* are very common in the plankton in all except the hottest months. There are five free-swimming larval stages. They resemble very closely to those of the American species, *H. emerita* (talpoida), the first stage of which was described by Faxon, and the last three stages by S. I. Smith. The two species differ, however, in respect of the disappearance and reappearance of the abdominal appendages in their post-larval life.

17. Yolk formation in *paratalphusa hydrodromus*.

A. NARAYAN RAO, Bangalore.

On examining a series of sections of the ovary of this freshwater crab prepared by Osmic technique the author has observed that the formation of fatty yolk by the Golgi vesicles is in accordance with the findings of Nath (*Q.J.M.*, Vol. 74, No. 296). While the albuminous yolk could be traced to Mitochondria, an observation which is in accordance with the findings of King (*P.R.S.*, Vol. 100, No. 700). Nowhere in his own preparations the author could discover the nucleolar extrusions which, according to Nath, are the active agents in the formation of albuminous yolk. The paper further discusses the collateral problems arising from these observations.

18. A short review of the Myriapod collection in the Indian Museum, Calcutta.

M. B. LAL, Lucknow.

The present paper is the outcome of the author's short stay in Calcutta during the summer of 1930 when he had the opportunity of examining the Myriapod collection in the Indian Museum.

The collection is very useful though by no means rich, as either the coastal regions or some hilly places have been explored; while very little collection has been made from the interior of the country.

For the purpose of showing clearly the extent of exploration for the collection of Myriapods, the author has given about a dozen outline maps of India, Burma, and Ceylon, and located the places from which collections have been made. A glance at the maps gives an idea of the immense work lying before the Zoologists for the study of this group as no collections have been made from vast stretches of the country.

The author has also collected and located some forms of Diplopoda (millipedes) which were not in the museum collection. A detailed list of the genera and species, together with their places of collection, is also given.

19. Preliminary notes on the copulation, fertilisation, and egg-laying of the millipede, *Thyropygus malayus*.

M. B. LAL, Lucknow.

Bhatia and Choudhary (1927) described copulation in this millipede, though under a wrong name of *Spirostreptus* Brandt., but their observations seem to be both scanty and inaccurate. The millipedes have been identified as *Thyropygus malayus* and complete and detailed observations are recorded in this paper.

The following important points may be noted in this connection:—

1. Copulation lasts as long as 20 to 40 minutes if the animals are left undisturbed.
2. The animals, while copulating, do not separate if carefully handled, though even the slightest sound vibrations, e.g. tapping of the table on which the dish containing the animals is kept, disturbs them.
3. There is a period of excitement for the male after which it never likes to copulate.
4. There is a jerking movement every 3 or 4 minutes by which the Gonopods press firmly against the vaginal discs, and this movement is very much pronounced at the end of the copulating process after which the animals separate.
5. Copulation is generally observed in nature from July to November. Copulation ceases during the winter months when the animals hibernate.
6. Eggs may be laid on the third day after the last copulation, or as late as 5 to 9 or even 13 days after.
7. Eggs do not develop if even slightly exposed to air, hence eggs are laid singly in small egg-capsules of earth which serves for protection during development. As many as 31 egg-capsules were collected from a single female.

20. On the chemical nature and physiological significance of the so-called 'Stink-glands' of *Thyropygus malayus*.

M. B. LAL, Lucknow.

These glands lie on the lateral walls of the chitinous body rings but are absent from the first five segments, including collum, and from the last or anal segment. They open outside as longitudinal slits through

which comes out a yellowish pungent fluid when the animals are handled. On irritation, however, the animals pour out considerable quantities of this fluid.

Microchemical tests were applied for detection of Hydrocyanic acid which is present in exceedingly small quantities. The author has also been able to detect minute quantities of free chlorine in the secretion.

The probable function of the glands is protective. Millipedes are quite unpalatable due to this fluid and very rarely preyed upon and eaten. Secondly, the hydrocyanic acid and free chlorine act as a sort of disinfectant and keep the surrounding soil and decaying vegetable matter where the animal lives free from bacteria and other micro-organisms.

Quantitative estimation of chlorine and hydrocyanic acid is being carried out. Details of the experiments are given in the paper.

21. On the egg-laying in *Strongylosoma* and *Orthomorpha*.

M. B. LAL, Lucknow.

Several local millipedes were collected and kept in laboratory under observation. Eggs were laid in clusters and in small pits in the soil. Egg-laying begins in early rains as soon as the animals come up on the surface. In *Strongylosoma contortipes* Attem., the number of eggs varied from 127 to 185 with different individuals. Eggs are red in colour. In another variety of *Strongylosoma*, viz. *Strongylosoma contortipes*—Forma minor—eggs varied from 78 to 93 in number and are pale yellow in colour: while in *Orthomorpha modestine* Silv., eggs are absolutely white and numbered from 38 to 60 with different individuals.

22. On the faecal pellets of millipedes.

M. B. LAL, Lucknow.

The millipedes are mainly vegetable feeders but they also swallow considerable quantity of earth along with their food, which they pass out in form of small beads. These faecal pellets resemble more or less the castings of *Pheretima*. They measure 5 mm. in length, and 1 to 2 mm. in width in case of *Thyropygus* Malayus, but they are as small as mustard seeds in case of smaller millipedes. Swallowing of earth is done during burrowing when the Labrum works like a spade and though the feet help in throwing the earth backwards still a lot is engulfed.

23. Notes on some Indian Thysanoptera with brief descriptions of new species.

T. V. RAMAKRISHNA AYYAR, Coimbatore.

This paper includes the results of the author's recent studies on the systematics and bionomics of some Indian Thysanoptera, and forms a supplement to them. Part of the material on which the present study is based was collected from sandal wood trees growing in the important sandal areas of Coorg and Salem by officers of the Imperial and Madras Forest Departments. The study of sandal 'thrips' forms a part of the investigation of the complete insect fauna of this valuable tree undertaken in connection with the 'sandal spike' which is believed by some scientists to be an insect-borne virus disease causing loss to the extent of over five lakhs of rupees per annum. It may also be added that such a faunistic work would represent the first intensive study of the insect fauna of a single species of forest tree in the Indo-Malayan region, and this would undoubtedly form a substantial contribution to our knowledge of the fauna of South India. The rest of the material includes

collections made by the author and others from the different parts of the country both on sandal and other host plants.

Of the following two dozen insects noted in the paper, eight happen to be species new to science and five are forms not previously recorded from India. Eleven species are from material collected on sandal wood tree and of these, two are extremely interesting giant forms new to science. Short notes on the different forms and very short descriptions of the new species make up the major portion of this paper.

SPECIES NOTED :

1. *Erythrothrips asiaticus*, R. and M.
 2. *Hemianaphothrips palmæ*, n. sp.
 3. *Pseudodendrothrips ornatissimus*, Schm.
 4. *Parthenothrips dracænæ*, H.
 5. *Heliothrips indicus*, Bag.
 6. *Thrips florum*, Schm.
 7. *Tæniothrips chætogastra*, n. sp.
 8. *Panchætothrips indicus*, Bag.
 9. *Ecacanthothrips fletcheri*, n. sp.
 10. *Liothrips dampfyi*, Ky.
 11. *Haplothrips inquilinus*, Pr.
 12. *H. Ganglbaueri*, Schm.
 13. *Trybomiella ramakrishnæ*, Ky.
 14. *Dolichothrips indicus*, H.
 15. *Karnyothrips nigriflavus*, n. sp.
 16. *Androthrips coimbatorensis*, n. sp.
 17. *Ramakrishnaiella nirmalapaksha*, R. and V.
 18. *Mallothrips indica*, Ramkr.
 19. *Dinothrips sumatrensis*, Bag.
 20. *Elaphrothrips beesoni*, n. sp.
 21. *E. chandana*, n. sp.
 22. *Neosmerinthothrips fructum*, Schm.
 23. *Kleothrips gigans*, Schm.
 24. *Idolothrips tungabhadræ*, n. sp.
24. A note on the gut and nervous system of the adult female lac insect *Laccifer lacca*, Kerr (Coccidæ).

P. S. NEGI, Namkum.

The internal anatomy of the female lac insect is a much neglected subject. Dr. A. B. Misra in his papers 'On the post-embryonic development of the lac insect' and 'On the internal anatomy of the female lac insect', has erred in his observations and mistaken the *Consolidated ventral ganglia* for the pharynx, and has stated that the nervous system is broken into separate parts. The paper disproves these observations of Dr. Misra, and states that the pharynx is only slightly bigger in diameter than the oesophagus. The bunch of salivary glands of either side with its common duct is closely attached to the consolidated ventral ganglia. The disposition of the gut is not materially affected by the distortion of the shape of the lac insect, and 'the free ends of the malpighian tubes and the blind end of the recurrent intestine' are directed towards the posterior end of the insect.

The nervous system is continuous and not broken into separate parts. It consists of the Cerebral ganglia; the connectives join to form the consolidated ventral ganglia which gives nerves to the anterior parts and continues posteriorly into the nerve chord for a short distance; the nerve chord then divides into two main branches which divide and subdivide to supply the various posterior parts of the female.

25. Anatomy of the worker ant *Dorylus orientalis*.

D. MUKERJI, Calcutta.

The writer showed the phylogenetic affinities of the Dorylinæ to the vespid on the basis of the internal anatomy of the male ant *Dorylus* (*J.P.A.S.B.*, XXII, 1927). In the present paper the internal anatomy of the blind worker ant *Dorylus orientalis* is investigated. The existence of well-developed ovaries in a few of the major workers and presence of air sacs in the workers which are non-winged as in other examples of ant, peculiar in leading a subterranean and nomadic life, deserve special mention. The workers are carnivorous and not vegetable feeders as reported by previous authors. The max-palp is one jointed and not two.

26. Note on the bionomics and rearing technique in the study of a Eulophid parasite.

K. P. ANANTANARAYANAN, Coimbatore.

In India, so far as the writer is aware, very little has been done with regard to the details on the life history and the technique of rearing of Hymenopterous insects belonging to the group of chalcid flies though it is long recognised that they are one of the most numerous and useful of the groups of insects. The present paper is an attempt in this direction, based on the writer's observations on a parasite of the Hymenopterous family which the writer had the opportunity to rear in large numbers for the control of the coconut caterpillar in Malabar, during the past five years.

In this paper are included the details as to the life history and habits of the parasite, the rearing technique in the laboratory, and the results of the preliminary investigations on the influence of weather on the breeding of the parasite, together with the work of the insect in nature.

This Eulophid is one of the important parasites indigenous to Malabar, and found comparatively the most efficient of the natural enemies of the coconut caterpillar for utilising it as a method of biological control. It may be added that the details with regard to the life history and habits of this parasite on coconut caterpillar have not been recorded before.

27. The termites of Orissa, their behaviour, and some effective methods of prevention.

S. K. GHOSE, Cuttack.

Affecting buildings, the author describes in detail the survey of termites found in Orissa, and gives a critical review of their behaviour and systematy.

The preventive measures suggested are bound up with the use of arsenic in the foundation of buildings, pitch and cement in the walls and floors, and reinforced concrete in place of woodwork, and special treatment of wooden material.

The economic aspect of the problem is dealt with.

A collection of termites obtained from different parts of Orissa were exhibited in the meeting.

28. On the habitat of the *Maruina*-type of Psychodid larvæ in India (insecta : Diptera).

S. L. HORA, Calcutta.

The *Maruina*-type of Psychodid larvæ resemble superficially the larvæ of the Blepharoceridæ and, like them, are provided with a row

of (6 to 8) ventral suckers. The Blepharoceridæ live in swift currents adhering to smooth rocks and boulders; whereas the '*Maruina*' larvæ live round waterfalls on rocks, stones, and pebble which are either constantly washed by spray or moistened by dripping water from above. They avoid strong currents and live either entirely out of water or in shallow, gentle currents at the sides of torrential streams. They have been found in India at Dalhousie in the Western Himalayas and in streams near Teesta Bridge below Darjeeling. The present note is written with a desire to direct the attention of future collectors to the type of habitat in which to look for them in this country. The structural peculiarities of these larvæ and their evolutionary significance are indicated. From the known distribution of such archaic forms as *Deuterophlebia*, *Maruina*, and the Blepharoceridæ it is suggested that they may have evolved independently on different continents under the influence of a set of same or similar environmental factors.

Notes are given on the methods of collecting and rearing these interesting flies.

29. On the Cytoplasmic inclusions in the oogenesis of *Periplaneta americana* (Linn.).

V. D. RANADE, Allahabad.

The oogenesis of *Periplaneta americana* (Linn.) has been studied both by intra-vitam examination and fixed preparations. Centrifuge experiments have also been carried out.

In the oocytes treated with dilute neutral red for about 20 minutes, the vacuome is tinged red and generally becomes prominent. In the earlier oocytes there are one or two patches of vacuome consisting of about five or six discrete round bodies. With the growth of the oocyte these patches increase in number and are uniformly distributed throughout the oocyte. In an advanced oocyte separate discrete vacuome are also clearly visible among the large and prominent patches of vacuome.

The Golgi vacuoles are not stained by neutral red and appear as refractory bodies which on the introduction of 2% osmic acid under the cover-slip clearly show the osmiophilic rim around a colourless core. In the oocytes treated only with 2% osmic acid for 20 minutes the vesicular Golgi bodies with chromophilic rim and chromophobic core are clearly seen. There are also some crescent-shaped Golgi bodies. In the youngest oocyte the Golgi bodies aggregate in a juxtannuclear position forming the yolk-nucleus of Balbiani. From now onwards they distribute in Cytoplasm in patches. With the growth of the oocyte, the Golgi bodies grow in size and begin to deposit fat in their central core and become converted into fatty yolk bodies. Precisely similar stages of the growth and the dispersal of the Golgi bodies were also observed in the fixed preparations. Golgi bodies are also derived from the follicular epithelium cells of the oocyte by the process of 'infiltration'. Golgi bodies make their appearance after prolonged treatment (25 minutes) with Janus green B in the intra-vitam examination.

In the oocytes treated with a dilute solution of Janus green B for 10 minutes the mitochondria are seen as fine granular bodies. There are also present baton-shaped mitochondria, some of which may be seen breaking into granular mitochondria. In the youngest oocyte they are aggregated in the juxtannuclear position to form the yolk nucleus of Balbiani. In the advanced oocytes they are distributed in patches, and ultimately they get evenly distributed in the Cytoplasm as granular bodies. Mitochondria, like the Golgi bodies, swell up and directly give rise to albuminous yolk. There is no evidence of nucleolar extrusions in the solid form.

30. Spermatogenesis in *Orthacris* (acrididæ).

T. RAMACHANDRA RAO, Bangalore.

The paper deals mainly with the chromosomes and their behaviour in the male germ cells of *Orthacris* sp. of the subfamily Pyrgomorphinæ. There are 19 chromosomes made up of 9 pairs of homologous chromosomes and the odd X-element. While ordinarily the form of all these chromosomes is uniform. In one of the individuals studied there occurs regularly in all the nuclei of the first spermatocyte metaphase, a J-shaped tetrad due to the presence of a pair of heteromorphous homologues.

The process of synopsis and related phenomena are described in detail, and are found to resemble in main outline the same phenomena in *Mecostethus* (McClung, 1927). Indications of the presynoptic split and the precocious behaviour of the X-element are clearly described. Certain differences are however noted. Even a close examination does not reveal the presence of protoplasmic processes between adjacent cells during diakinesis. An attempt is made to study the segregation of the unequal homologues in relation to the sex chromosomes. The rôle of centrioles in sperm formation is briefly outlined.

A comparative study of these processes in *Aularches miliaris* (Linn.) is also made.

31. A note on Gude's classification of *Cyclotopsis*.

R. V. SESHAIYA, Annamalai Nagar.

The paper points out the incorrectness of Gude's inclusion (*Fauna of British India-Mollusca*, Vol. II) of the genus of *Cyclotopsis* in the family of Cyclophoridae. An examination of *Cyclosopsis subdiscoidea* (Sowerby.) shows the characteristic features of Potamiasidae (=Cyclostomatidae) in (1) the presence of a deep longitudinal pedal groove, (2) the concentration of the pedal centres, (3) the presence of a single otolith in the otocyst, (4) the structure of the reproductive system, (5) the structure of the radula, and (6) the absence of jaws.

32. Anatomy of *Paludomus tanschaurica* (Gmelin).

R. V. SESHAIYA, Annamalai Nagar.

The paper gives a preliminary account of the anatomy of *Paludomus*. Among other features, it describes the oligopyrene and eupyrene types of sperms found in the species, the peculiarities in the pallial circulation and the function of the marginal processes of the mantle. A definite blood-sinus corresponding to the 'vena circularis' of Pulmonates is present in the anterior part of the mantle. A sinus of this type does not seem to have been recorded till now in any of the aquatic Prosobranchs. The 'vena circularis' of *Paludomus* receives venous blood from definite sinuses in the marginal processes of the mantle. From the 'Vena circularis', the blood flows through ramifications on the left side of the mantle into the efferent ctenidial vein. The marginal processes seem to serve as accessory respiratory organs.

33. A note on the mucous glands in the foot of *Ariophanta*.

T. K. GOPALACHARI, Cocanada.

(Communicated by Mr. R. V. Seshaiya.)

The paper gives an account of the different types of mucus-secreting glands found in the foot of *Ariophanta*.

34. The spicules and their variation in *Salmacis bicolor* and *Stomopnustes variolaris*.

M. KRISHNA MENON and R. GOPALA AIYAR, Madras.

The paper deals with the occurrence and distribution of spicules in *Salmacis bicolor* and *Stomopnustes variolaris*. Spicules are described in *Salmacis bicolor* from the gonads, the reproductive ducts, cœlomic epithelium, alimentary canal, tube feet, ordinary and buccal, buccal membrane, stone canal, axial sinus and gills. The spicules are of two varieties both belonging to the bihamate type. Variations are common in the spicules from the gonad, but absent in the other portions of the body. The percentage of variation is noted. A detailed description of the spicules in various regions of the body is given. An attempt has been made to note if there is any relation between the size of the spicules and the size of the individual.

In *Stomopnustes variolaris* in spite of its otherwise robust appearance spicules are conspicuous by their poor development. The bihamate type is absent. The gonads do not contain any spicules amongst the germ cells. But the membrane surrounding the gonad often possesses spicules of an irregular type. In the alimentary canal in the beginning and the end scattered triradiate spicules are observed. The perforated plates of the tube feet are described. The buccal membrane and gills also contain scattered plates of a similar nature.

35. On certain hitherto unknown characters in the Fam. *Notopteridæ*.

M. RAHIMULLAH and B. K. DAS, Hyderabad.

So far only two distinct species of the genus *Notopterus* have been recognised as known to be distributed practically all over India. Their taxonomic position depends upon the following characters :—

1. The presence or absence of a concavity over the upper profile of the head.
2. The presence or absence of the serrations towards the lower edge of the preorbital.
3. The variation in the number of serrations along the abdominal edge between the throat and the insertion of the ventral fins.
4. The number of dermatrichia in the continuous anal and the caudal fins.
5. The extension of the maxilla in relation to the orbit.
6. The position of the dorsal fin.

Comparing the data given for the species of *Notopterus* in the *Fauna of British India*, 'Fishes' with those of the specimens (more than four dozens examined), obtained from the river Mûsi which present several variations and new characters, the following points are worthy of mention :

- | | | | |
|-------------|-----------|-----------|-------|
| (a) B. VII. | D. 8-10. | P. 14-15. | V. 5. |
| A. 99-102. | C. 10-13. | L1. 180 | |
- (b) Concavity over the dorsal surface of the head quite prominent.
 - (c) Serrations existing along the lower surface of the Preorbital.
 - (d) 28-31 serrations along the abdominal edge.
 - (e) $A + C = (95-102) + (10-13)$.
 - (f) Extension of Maxilla ventrally = $\frac{1}{2}$ to $\frac{2}{3}$ of the diameter of the orbit.
 - (g) Dorsal fin commences much nearer the tail than to snout.

Taking all the facts into consideration the authors find that the problematical type of *Notopterus* embraces the characters of both the species of the genus *Notopterus*. It comes more or less near to *kapirat* in the following respects :—

- (i) Composition of the caudal fin.
- (ii) Composition of the anal fin.
- (iii) Serrations present along the ventral surface of the Preorbital.

Further details of similarity and differences, etc. are given in the paper.

In the opinion of the authors this seemingly new group of fishes of the genus *Notopterus* forms what might be called a *local race*, as if emerging from the almost cosmopolitan stock of *kapirat*. To be brief, in some respects they possess certain characters which are undoubtedly intermediate between those of *kapirat* and *chitala*, while in other respects they are widely different from either of them.

36. Observations on the confluence of the median fins in one of the common cat-fishes of the Nizam's Dominions, Mároof (Mahgur or Mângri—*Clarias batrachus*).

M. RAHMULLAH and B. K. DAS, Hyderabad.

Confluence of the median fins has been noted and studied in two examples of the Cat-fish, Mároof (*Clarias batrachus*).

(a) In the first case :

- (i) All the three vertical fins (dorsal, caudal, and anal) are confluent with one another; that is to say, they form one continuous vertical fin-fold.

$$D + C + A = 80 \text{ rays.}$$

- (ii) The primary caudal fin (homocercal) is severed off, probably due to certain accidental causes, and in its place a new tail-fin is regenerated as a secondary acquisition round the much abbreviated caudal axis.
- (iii) The endoskeleton in this case is very much modified: no trace of the urostyle and the hypurals—the terminal part of the vertebral column is slightly deflected upwards. All the dermatrichia of the last portion of the anal as well as the dorsal fins bend towards and encircle round the caudal axis.

(b) In the second case :

- (i) Only the dorsal and the caudal fins are united together, this condition being intermediate in form between the first case and the normal type.

$$D + C = 73$$

↓

$$73 + A = 118 \text{ rays.}$$

Normal type: $D + C + A$ (all fins though quite separate and independent of one another) = 122 rays.

- (ii) The original homocercal caudal fin is retained, but there is a single much abbreviated hypural bone (as compared with a large, partly coalesced, vertically-directed, fan-shaped bony plate formed by the fusion of six hypurals in a normal type) supporting the whole of the spread-out hypochordal dermatrichia—five of the hindmost dermatrichia of the dorsal fin being crowded together and situated over the upper corner of the single hypural bone, and are thus enclosed within the common fin-fold.

(c) The dermatrichia in both the first and the second cases are abbreviated.

(d) The number of vertebræ in the caudal and the abdominal regions of the vertebral column in the first, second, and the normal cases

are 24 and 18 (=42), 35 and 19 (=54) and 36-37 and 18 (=54-55) respectively. This clearly shows that the vertebral elements in the first case are nearly $\frac{2}{3}$ of those of the normal type.

(e) In certain fishes the median fins may be very rudimentary (symbranchidæ); imperfectly or well developed in Elasmobranchs and other bony fishes. Dorsal fins may be normally confluent with the caudal (*Chaca lophioides*), or all the three vertical fins might be united together as in *Plotosus*. In a few other Indian fishes the caudal fin is united with the anal (*Callichrous*, *Coila*, *Notopterus*, etc.). Other cases where the confluence of all the three median fins exists are: Murænidae, Gobioides, Trypauchen, Cepola, certain Rhynchobdellids, most Ophiidæ, a few Pleuronectids, Dipnoi, etc.

37. On the hypobranchial artery of *Labeo calbasu* (H.B.) and *Mugil corsula* (H.B.).

E. GHOSH, Calcutta.

Labeo calbasu.—The hypobranchial artery arises from the first and second efferent branchial vessels of the left or of right side, or of both sides, the mode of origin in the last case being similar to that in *Cirrhinus mrigala* and *Catla catla*. The artery passes backwards along the right or left side of the ventral aspect of the ventral aorta. It ends in the ventral aorta just beyond its origin from the bulbus arteriosus. Branches are given to the urohyal region, pectoral region, and to the pericardium. The bulbus arteriosus is produced into two lateral, elongately triangular diverticula. Efferent branchial vessels arise separately. First and second efferent branchials unite to form the first epibranchials which fuse to form the dorsal aorta. The third and fourth efferent branchials fuse to form the second epibranchials which open into the dorsal aorta.

Mugil corsula (H.B.).—The hypobranchial artery arises from the second pair of efferent branchial vessels and also receives the third pair of efferent branchials. It does not supply the heart, but is continued to the pectoral region, giving branches to the urohyal region. The ventricle is elongated and its apex overlaps the bulbus arteriosus on the ventral aspect in the form of a rounded sac. The first three pairs of efferent branchial vessels arise at equal distances from one another. The fourth pair arise immediately behind the third from the ventro-lateral aspect of the ventral aorta. The first two efferent branchials unite to form the first epibranchial which runs backwards in a widely S-shaped curve and unites with its fellow of the opposite side to form the dorsal aorta. The third and fourth efferent branchials unite to form the second epibranchial which ends in the dorsal aorta. There are two slender accessory efferent branchial vessels from the third and fourth gills which unite to form a common trunk ending in the dorsal aorta immediately in front of the second epibranchial artery.

38. Studies on the Asphyxiation of some air-breathing fishes of Bengal.

E. GHOSH, Calcutta.

The study of the mode of respiration in air-breathing fishes has already been made by Rev. Boake, Day, Dobson and Das, who devised experiments so as to prevent access to free air. The results were that the fishes died of asphyxiation after certain periods which varied in different cases. The experiments are repeated here. It is found that the periods of death are in all cases lengthened out. Conclusions: (1) The shorter period in the previous experiments was due to asphyxiation from deficiency of oxygen in water. (2) Air-breathing is not the only method of respiration in them, to the exclusion of water-breathing; but it rather supplements water-breathing to a more or less degree. The fishes experimented

upon are: *Amphipnous cuckia*; *Mastacembelus pancalus*, *M. armatus*, *Rhynchobdella aculeata*, *Anguilla anguilla*, *Saccobranchus singio*, *Clarias magura*, *Anabas scandens*, *Trichogaster lalius*, *Ophiocephalus striatus*, *O. punctatus*, and *O. gachua*. The two species of *Mastacembelus* and *Rhynchobdella aculeata* survived immersion for two to three days. Hence their aerial mode of respiration is an additional equipment for living out of water for some time.

39. On the branchial innervation of a few Teleostean fishes.

G. K. CHAKRAVARTY, Calcutta.

The investigation regarding the nerve supply in the gills of *Labeo rohita*, *Labeo calbasu*, *Cirrhitina mrigala*, and *Cailla catla* has revealed some difference from the mode of branchial innervation generally met with in Teleostean fishes. Instead of being supplied by the glossopharyngeal nerve only the first gill has its nerve supply partly by the glossopharyngeal and partly by the first branchial branch of the vagus. Unlike the general way where the second, third, and fourth gills are supplied by the first, second, and third branchial branches of the vagus respectively, the second, third, and fourth gills in these fishes have got some variation in the nerve supply. The second gill is supplied by the first and second branchial branches of the vagus, the third gill is supplied by the second and third branchial branches, and the fourth gill is supplied by the third branchial branch and another nerve emanating from the vagus. In addition to these nerves supplying the posterior region of the four gills, there are nerves which originate from the branchial branches of the vagus and supply the anterior region of the gills in different ways in different fishes.

40. The bionomics of a loach-like Siluroid fish *Amblyceps mangois* (Ham. Buch.).

S. L. HORA, Calcutta.

Amblyceps mangois is a long and slender fish that inhabits small streams at the base of hills in northern India, Burma, and Siam. The species varies considerably, especially with regard to the form of the caudal fin, the length of the adipose fin, the height of the body, etc., and has, consequently, been described under several names. A study of large material has shown that the genus, so far as known at present, is monotypic.

The author has observed this fish in its natural haunts in the Sevoke Stream in the Tista Valley below Darjeeling. It is a small stream with pebbly bed, and clear, rapid-running water. *Amblyceps* lives at the bottom where it can crawl with great agility and is able to seek shelter in holes and crevices among rocks and stones. An important factor in the habitat of the fish is the seasonal change in the volume of water in the stream. After a freshet the stream becomes a raging torrent, whereas during dry months it is cut up into a series of pools and puddles. *Amblyceps* appears to be fully adapted to these adverse conditions of existence.

41. The morphology of the skull of the Siluroid fishes.

B. S. BHIMACHAR, Bangalore.

This paper which embodies the results of an investigation of the osteological characteristics of the skull in the type forms of eight Indian

genera of Siluroids, deals primarily with the following features: There is a gradual ossification and specialization of the skull, more or less, in the following order—*Silundia*, *Plotosus*, *Wallago*, *Rita*, *Pangasius*, *Macrones*, *Arias*, and *Osteogeneosus*. The cranium slopes gradually before forwards. The skull is deeply situated in the primitive genera and becomes secondarily superficial in the higher forms. There is a well-developed orbitosphenoid, a suprasphenoid (fused with parasphenoid) and generally a toothed vomer. The cranium is platybasic and there is a thin cartilaginous internasal septum. The myodome is absent but a small trace of it is present in the primitive *Silundia*. There is generally a strong supraoccipital process. In the higher forms there is a rigid attachment with the cranium of the post-temporal and the complex vertebra the latter with secondary articulations also. The suborbitals and nasals are thin tubular bones. Two pterygoids are constant in all the forms. Palatines and maxillaries have undergone great modification. In two forms there are vestiges of the subopercula. The opisthotics and the parietals are absent.

42. The skull of *Ophiocephalus striatus*.

B. S. BHIMACHAR, Bangalore.

The present paper is based on a comprehensive study of a large number of skulls of *Ophiocephalus striatus* and records among other features, the following most salient characteristics.

The bones on the dorsal surface of the cranium are large and are compactly articulated. There is no fontanelle. There is a small supra-occipital process and two epiotic lamellæ. The parasphenoid is long and possesses a small oval patch of teeth. Vomer is broad, toothed and extends in front of the supraethmoid. Orbitosphenoid is absent. There is a small suprasphenoid. The posterior myodome is closed behind. There is an anterior myodome on either side of the supraethmoid. The exoccipitals do not meet below the foramen magnum and each presents posteriorly an oval vertebral articular surface. The upper portion of the auditory region is compressed and on either side is a wide shallow recess below the parietal. This recess with an inwardly directed lamella of the hyomandibular forms the bony covering of the accessory air-breathing chamber. There are three pterygoids and a toothed palatine. The maxillary is edentulous. These points are discussed from a comparative standpoint of the allied groups.

43. The relative condition of brain in fishes with reference to their habit and habitats.

B. K. CHATTERJEE, Calcutta.

(Communicated by Himadri K. Mookerjee.)

In studying the relative conditions of the brains in certain freshwater Teleostean fishes of Bengal, with reference to their habits and habitats, numerous variations as regards the structure, size, and weight of the brain were noticed.

44. The golgi bodies in the erythrocytes of fishes.

D. R. BHATTACHARYA and S. P. BANERJI, Allahabad.

The occurrence of golgi bodies in the red blood-cells of reptiles and birds have been described by Bhattacharya and Brambell. This is the first time that they are being described in the erythrocytes of fishes. The authors examined a number of fishes and noticed the presence of golgi bodies as discrete elements in a diffused condition in the blood-cells of *Ophiocephalus punctatus* and several other fishes. The Da-Fano

slides proved to be less satisfactory than Ludford preparations. The golgi bodies lie mostly in a juxta-nuclear position and form a cap-like investment around the nucleus. They are granular in shape and are visible only with the aid of a high power oil immersion lens.

45. On certain peculiarities in the Vascular system of *Cacopus systoma* (Schneid).

M. S. MUTHUSWAMY IYER, Bangalore.

The following peculiarities are noticed in the Vascular system of this Engystomatid Toad :

1. Prolific branching of the Laryngeal artery into at least four principal branches.

2. The transverse Iliaco-communicans tends to shift anteriorly and opens into either the Reno-portal vein as in some or branches in the substance of the kidney.

A few other minor variations are also described.

46. On the Tympanic Membrane of certain Engystomatidæ.

L. S. RAMASWAMI, Bangalore.

The tympanic membrane described in text-books such as Ecker's Frog is fibrous and is stretched and held in position by the cartilaginous Annulus Tympanicus. The skin covering the membrane is thinned out. In *Bufo* the tympanic membrane is no doubt as in *Rana* and the skin covering the membrane has lost the glands though the small tubercles are present. In *Cacopus* the tympanic membrane has become cartilaginous and is situated at the angle of the mouth. This tympanic membrane is unattached to the overlying skin, which histologically is exactly like the skin in the other parts of the body. The attachment of the columella to this cartilaginous tympanum and the structure of the middle and the internal ear form the subject matter of the paper.

This extraordinary modification of the tympanic membrane is in accordance with the singular life habits of the animal.

47. The heart of *Uraeotyphlus menonii*.

K. KARUNAKARAN NAIR and A. SUBBA RAU, Bangalore.

The description of the structure of the heart of this amphibian is given.

48. On the arterial arches of *Uraeotyphlus menonii*.

H. K. MOOKERJEE and B. K. CHATTERJEE, Calcutta.

In the vascular system of *Uraeotyphlus menonii* certain peculiarities in the disposition of the arterial arches were observed. From the long and stout truncus arteriosus, arise the four trunks simultaneously, (1) two systemic, and (2) two pulmonary. The two pulmonary trunks run only a short distance with the systemics, and then, relative to the inequality and asymmetry of the lungs, they are unequal in size and asymmetrical in disposition. The systemic trunks are long and extend up to the base of the skull where they arch back and unite with each other behind the apex of the heart, to form the Dorsal Aorta. The carotids arise from the systemics at the points where they bend down. The ductus botalli are distinct elongated vessels running along the systemic trunks.

49. Notes on the peculiar apertures in the vertebral-centra of *Typhlops braminus*.

H. K. MOOKERJEE and G. M. DAS, Calcutta.

It has been observed from an alizarine preparation of transparency of *Typhlops braminus* that each vertebra has an aperture in the middle of the ventral surface of the centrum towards the anterior half. These apertures are present throughout the vertebral column up to the pelvic region beyond which in the tail vertebrae they are absent.

50. On the urinogenital organs of common Indian lizard—*Calotes versicolor*.

J. DAYAL, Lucknow.

Very little is known about the urinogenital organs of the common Indian lizards. The kidneys lie at the posterior end of the abdominal cavity and the ureters open into a dorsal pouch of cloaca (Urodæum). The testes are paired organ lying far forwards in the abdominal cavity by the side of the vertebral column. The Vasa-defferentia open separately into the urinary chamber. Copulatory organs are present in the males. The ovaries also lie in the middle of the abdominal cavity. The oviducts open anteriorly into the abdominal cavity and posteriorly into the cloaca.

A detailed account of the urinogenital organs is given. The paper concludes with a comparison of its urinogenital organs with those of *Hemidactylus* and *Uromastix*.

51. On the so-called three species of *Cylindrophis* Wagler.

B. C. MAHENDRA, Agra.

The author has made a careful examination of a fairly representative collection of snakes belonging to the genus *Cylindrophis* Wagler, and he finds that the so-called 'specific' features between *Cylindrophis maculatus* Linné, *C. rufus* Laurenti, and *C. lineatus* Blanford do not really serve to mark off one 'species' from the other. All these features grade indiscriminately, and there is actually no discontinuity, which can be regarded as sufficient ground for instituting three species. He suggests that the three forms be regarded as colour varieties of the same species *C. maculatus* Linné.

It is also shown that the colour pattern in *C. rufus* is a modification of the one found in *C. maculatus*. In the latter, the black network enclosing two series of spots along the back is formed by three longitudinal stripes visible from above and a number of alternating cross-bands. In the former, the arrangement is the same, but the longitudinal stripes are absent, thus leaving a number of half cross-bands on the body, alternating with each other.

52. The yolk nucleus of Balbiani in the Oogenesis of *Columba intermedia*.

R. S. DAS, Allahabad.

In Da Fane's silver nitrate preparation and also in Mann Koosch as modified by Ludford it has been observed that the initial focus of growth of golgi bodies and mitochondria is restricted to the centrosphere area juxtanuclear in position. This area is also seen in the preparation of histological fixatives carrying centrosome with a centriole. In young oocytes, this archoplasmic area seems to be the seat of the greatest activity in the cell. The cytoplasm in this area is of much denser consistency and in their earlier stages golgi bodies and mitochondria are restricted

to this area only. In other words this area or as D'Hollander calls it 'Yolk nucleus of Balbiani' is the seat of important vital functions in the life of an oocyte.

53. On a cyclopiian chick monster.

M. B. LAL, Lucknow.

This chick monster collected locally shows four developing wings and four posterior limbs. Head and other parts are normal.

Details of the Monstrosities are discussed in the paper.

54. The skeletal system of a microchiropteran, *Rhinopoma microphyllum*.

H. K. MOOKERJEE, Calcutta.

The salient features of the skeletal system are as follows:—

1. Neural spine in fourth, seventh, and eighth thoracic vertebrae.
2. Ilium is articulated with the two vertebrae.
3. Ischium is articulated with another two vertebrae.
4. Pelvic girdle:—

(a) Epipubic bone or so-called Marsupial bone which is diagnostic feature of the group marsupialia has not hitherto been recorded in other mammalia except, of course, in the monotremata.

(b) Ischia having a symphysis in front.

55. The eyes of *Loris lydekkerianus*.

A. SUBBA RAO, P. R. SUBBA RAO, and S. HIRIYANNAIYA, Mysore.

The eyes were examined with the aid of the Ophthalmoscope and the slit lamp. The arrangement of the blood vessels and the general appearance of the fundus are described. The band pattern as revealed by slit lamp examination of the eye of this interesting Primate is recorded. A brief description of the structure of the retina is offered.

56. Notes on congenital abnormality of the limbs of man.

S. HIRIYANNAIYA and K. SUNDARESAN, Mysore.

(Communicated by Prof. R. G. Aiyar.)

Congenital absence of the Radius and Ulna in the upper limb and of the Fibula in the lower limb of a man is noted. The X-ray appearance of the knee-joint is given. The factors causing deformities of the limbs are discussed.

57. Cytoplasmic inclusions in the oogenesis of *Sciurus palmarum*.

MISS R. CLEMENT, Allahabad.

The oogenesis of the squirrel has been worked out by fixed preparations as well as by intra vitam and vital staining experiments. The golgi bodies appear in a juxta-nuclear position in young oocytes both in fixed and fresh preparations.

The golgi bodies in very early stages appear to form a network. Later on they present a vesicular or crescentic form having a duplex structure, an outer osmiophilic rim and a central chromophobic portion. In advanced stages of oogenesis, the golgi bodies form a peripheral ring

and yolk formation takes place at this stage by the swelling up of the golgi elements. The infiltration of golgi elements from the follicular epithelium to the egg can easily be demonstrated. Mitochondria appear in patches in fixed preparations. In early stages they are concentrated like golgi bodies in the 'Yolk nucleus of Balbiani' area. With the growth of the oocyte they are evenly distributed in the Cytoplasm, and do not appear to take part in Vitellogenesis. Distinct nucleolar extrusions are present but take no part in Vitellogenesis. By vital staining experiments particularly with neutral red the vacuome can be demonstrated. It is distinct from golgi bodies which remain unaffected by this dye. The yolk bodies are stained by Sudan III and Scharlach R. A number of vacuoles are present, in some cases having their interior filled with some sort of Coagulum. In the squirrel the yolk seems to be fatty in nature.

58. The ovary and the ovarian ovum of *Pteropus medius*, Dobs.

B. R. SESHACHAR and L. S. RAMASWAMI, Bangalore.

The paper records certain extremely interesting observations on the structure of the ovary and the ovarian ovum of *Pteropus* in different stages of growth and development. A careful examination of a large series of the sections of the ovary of this interesting bat points to the conclusion that there is a polar aggregation of younger ova while the fully formed ones are found at the opposite pole. The cytoplasmic inclusions like the mitochondria and the golgi bodies are periodic in their occurrence and are confined to certain stages in the developmental phenomena. Definite information is available as regards the rôle played by these inclusions in the elaboration of fat and vitellogenuous products. So far as the developmental phenomena of the oocytes are concerned *Pteropus* perhaps differs from the other members of the Chiroptera.

Section of Botany.

President :—DR. S. L. GHOSE, M.Sc., Ph.D., F.L.S.

Presidential Address.

SOME ASPECTS OF THE STUDY OF FRESHWATER ALGÆ, WITH SPECIAL REFERENCE TO THOSE OF INDIA.

Just five years ago Professor M. O. Parthasarathy Iyengar, in his presidential address to the Botany Section of this Congress, very admirably surveyed algal work done in India up to that time (66). At the end of the address he suggested some of the lines of research on algæ that could be profitably undertaken in India. It is gratifying to see that much greater interest in algæ has been taken since then. Some of our men have had special training in Algology abroad, and the prospect of the study of Indian Algæ is to my mind not so gloomy as it used to be a few years ago. One great drawback seems to be the fact that it is generally believed that the study of algæ in India can hardly be of any use from the economic point of view, and can bring to the investigator at the most only a certain amount of happiness as a result of purely academic and scientific achievement. While Mycology, Plant Breeding, and Plant Physiology are drawing most of our men for obvious reasons, subjects which are supposed to be of no more than academic interest fail to attract many of them. For this reason it shall be my special effort to-day to deal with the applied side of the study of algæ, to show what is being done in other parts of the world and to suggest what could be done, so that a scientific investigation of Indian Algæ could be made use of in things of public interest. It is not because I believe that a scientist should have a mercenary motive behind the study of his favourite subject, but because I feel that in these hard times of trade depression and financial stringency, it is very difficult indeed for most scientists to carry on research unless there is a prospect of legitimate opportunity and employment before them.

THE IMPORTANCE OF THE STUDY OF ALGÆ.

Algæ, using the term in its broadest sense, are supposed to be the simplest and the most primitive plants known so far. In fact it is generally believed that life must have first originated in water and the first living organism must have been of an algal type. It is clear, therefore, that a detailed study of algæ from cytological, biochemical, and physiological points

of view, must have a great bearing on the problem of the origin of life itself, the solution of which is the ultimate goal of all biologists. Other groups of plants most probably have evolved from these lowly organisms, and it would be very interesting indeed to investigate as fully as possible the various evolutionary tendencies exhibited by them. In his paper on 'Evolutionary Sequence and Affinities among Protophyta' Dr. Fritsch has beautifully dealt with this aspect of the study of algæ (40). Moreover, biological principles like division of labour and parallelism in evolution are likely to be more clearly understood by a careful and detailed study of this fundamental group, and explanations to the phenomena of formation of tissues and the plant-body, differentiation of somatic and reproductive cells, differentiation of sexes, alternation of generations, adaptation to land life, and to the origin, structure, and function of the various cell-bodies like the nucleus, plastids, blepharoplasts, pyrenoids, chondriosomes, and Golgi bodies, are more likely to be found by researches on this primitive group than on any other. Possibilities of research on this fascinating group, therefore, ladies and gentlemen, I wish to draw your attention to, in the short period of time allotted to me in which to address you. My only justification for selecting this subject for the address is my own personal interest in the group for the last 15 years. In reviewing the work done on it in India and abroad during the last 5 years or so, I do not in the least mean to pretend that all the contributions to our knowledge of freshwater algæ would be dealt with, but naturally I shall have much more to say about those algæ with which I have had to do personally. I must offer my apologies for such preferential treatment, but may at the same time venture to point out that it is next to impossible for one individual to give equal attention to all the groups of algæ and to all aspects of studying them.

SYSTEMATIC.

The doctrine of the flagellate origin of the 'algæ', using the term in its narrower sense, became firmly established more than 30 years ago. The separation of Green and Yellow-green Algæ on morphological and physiological grounds followed soon after. Blackman and Tansley distinguished Isokontæ and Heterokontæ as separate classes in their classification of the Green Algæ (8). While the Isokontæ are characterised by having motile stages bearing equal cilia arising from the anterior end, chloroplast, often few and large, usually provided with pyrenoids and containing pure green pigment, and by storing starch as their photosynthetic product, the Heterokontæ possess motile stages with two very unequal cilia attached at the front end, and chloroplasts which are many in number, commonly discoid, yellowish-green in colour due to an excess of xantho-

phyll, and with no pyrenoids, and by having oil as the product of synthesis. The Oedogoniales and the Conjugatæ show characteristics of the Isokontæ mostly, and have been taken to constitute members of the same class by Fritsch (106), so that Stephanokontæ and Akontæ are not recognised as separate classes. Parallelism between the Isokontæ and Heterokontæ with regard to the formation of plant-body is becoming increasingly apparent. Both classes have motile unicells, palmelloid and chlorococcoid types, dendroid colonies, unbranched and branched filaments, and cenocytic forms. Out of the two classes the Isokontæ have shown much more vigorous development both with regard to the variety of body-forms and to the method of reproduction; the Heterokontæ do not seem to have developed a motile colony and to have produced very few filamentous and siphonaceous forms, and also they do not possess a higher form of sexual reproduction than isogamy. All the ciliated and many palmelloid members of Heterokontæ exhibit clear 'flagellate' characters while similar members of the Isokontæ have developed the higher type of organisation characteristic of true algæ. Thus it would seem that 'algal' characteristics were assumed at different levels by the Isokontæ and the Heterokontæ. Not only have these two classes of algæ been derived from Flagellates, but it is believed that every series of holophytic Flagellates could potentially have acquired 'algal' characteristics. 'Algal' forms like *Chrysosphaera*, *Nematochrysis*, and *Thallochrysis* show clear and close relationship to the flagellate Chrysomonadales. In the same way, *Hypnodium*, *Phytodium*, and *Dinotrix* are taken to be the 'algal' members of the Peridineæ (Dinoflagellata) (40). So far as is known at present other classes of holophytic Protophyta like the Bacillariales, the Cryptophyceæ, the Chloromonadales, and Euglenineæ do not show both the 'flagellate' and 'algal' forms so clearly, but seem to have developed strictly along one side or the other. The Myxophyceæ possess only 'algal' forms and motile types are unknown. In this connection, however, it is interesting to note that recently motile forms resembling zoospores have been recorded in a culture of *Oscillatoria* (93). There have been two other records of motile forms in the Myxophyceæ before (55a, 26). How far these cases can be taken to indicate that at one time the Myxophyceæ also possessed motile reproductive organs remains to be decided by further research.

In short, it is recognised now that in all the classes of holophytic Protophyta mentioned above there has been a certain amount of parallel evolution, which has resulted in the production of similar forms of plant-body, ranging from a motile unicell to branched filaments. Of course, every one of these types is not found in all classes, but it is probable that future research will be found to fill up quite a number of gaps

as time goes on, and it should be the effort of the future algologists to try and discover them. 'Algal' forms of every series of holophytic Flagellates have not been found so far. In India the Chrysophyceæ and the Peridineæ have not been investigated at all, and very little work has been done on the whole group of Heterokontæ up till now. Practically nothing is known as to the freshwater representatives of these classes in our country.

In view of the above-mentioned ideas about the origin and relationships of true algæ, of late very great interest has been shown in the simplest types of them, and a large amount of work has been done on them in the various parts of the world. Fritsch, Rich, Carter, and Crow from England, Geitler and Pascher from Austria, Fremy and Raphelis from France, Skuja, Korshikow, and Woronichin from Russia, Borge from Sweden, Taylor, Tilden, and Tiffany from America have published numerous papers on the subject. It is also encouraging to learn that algæ from very different parts of the globe are being studied. Fritsch, Rich, Fremy, Raphelis, Groves, Schröder, Swerkeno have described some African Algæ (36, 37, 43, 44, 31, 32, 33, 34, 87, 56, 90, 95), Borge and Lundberg some Swedish ones (10, 71), Lindemann some Russian ones (70), Skvortzow and Wang some Chinese ones (91, 92, 101), and Bhardwaja, Borgeesen, Carter, Pal, Biswas, Handa, and myself have dealt with some algæ from India and Burma (2, 1, 11, 14, 80, 4, 5, 6, 7, 59, 58, 60, 61, 62, 50, 51, 52, 53, 54, 55). Enumeration of all the new forms described by the various authors would serve no useful purpose here, but it may be pointed out that while most of the papers published on algæ in Europe deal with the simplest types like the Volvocaceæ and the Peridineæ, in our country the latter do not seem to have attracted much attention. It is time, therefore, that effort should be made to make a study of the Indian Holophytic Protophyta, and I venture to believe that very many new and interesting forms will be discovered as a result of it.

ECOLOGICAL.

This aspect of the study of algæ is fairly recent. G. S. West was one of the first to classify freshwater algal communities and recognised three associations, subaerial, aquatic and that of dripping rocks (105). He and his father studied the British freshwater phytoplankton and came to the conclusion that rich Desmid floræ occurred in waters in the area of pre-carboniferous rocks, which were poor in dissolved mineral salts (107). Pearsall later on confirmed this and also showed that Diatoms and Myxophyceæ were found in lakes showing much silt deposition (83, 84). Naumann classified phytoplankton into oligotrophic and eutrophic formations, the former being characteristic

of waters poor in mineral nutriment and the latter of those rich in them (76). The oligotrophic formation is typical of more ancient rocks, has lower plankton productivity and is richer in species than the eutrophic formation. Its plankton is essentially green while that of the eutrophic type is mainly blue-green. The oligotrophic lakes are generally deeper than the eutrophic ones and have a narrower littoral shelf and poorer littoral vegetation. Thienemann recognises a third type—the dystrophic type—which is formed in moorland waters and is poor in mineral nutriment, but has an abundance of foreign organic matter (96). This type, however, is regarded by Naumann as a special form of the oligotrophic one (77). Thus the two types of waters generally recognised are the oligotrophic and the eutrophic. Of course, there are specialised forms of each of these, and there are intergrades between the two also: for instance, Pearsall has described the gradual transition of the oligotrophic type to the eutrophic one (83), while Gams has suggested a development in the reverse direction (45).

The different factors which go to determine these types of waters may be briefly considered here. They are (1) the sediment, (2) the depth and form of the lake, (3) the hydrogen-ion concentration, and (4) the surroundings of the lake.

(1) In oligotrophic waters the sediment is scanty and poor in mineral and organic substances, while in the eutrophic type it is rich in these. In eutrophic waters the organic matter is derived from the decay of the abundant plankton, while in dystrophic waters it is introduced from outside. In some eutrophic waters the sediment is formed by the introduction of dead foliage leaves from the surrounding woods. These leaves decay in part and form a yellowish-brown humus ooze.

(2) The depth and form of a lake have a great effect on its flora. As stated above oligotrophic lakes are generally deeper. They have a narrower littoral shelf and poorer littoral vegetation. In shallower waters a large amount of vegetation develops while in deeper ones the deficiency of oxygen and light and, in many cases, of heat, hinders its growth. In fact it has been found that the shallower the lake the greater would be the plankton productivity. In fairly deep eutrophic and dystrophic waters the lower layers have less oxygen-content because of the decay of the abundant plankton and the foreign dead organic matter respectively, so that a kind of stratification of the oxygen-content will be produced. In sheltered waters, near the bottom this stratification would follow the configuration of the bottom, while in exposed waters the stratification would tend to be horizontal on account of the mixing effect of wind and heat-currents. Thus it would seem that poorness in algal vegetation may be brought about by great depth as well as by lack of nutrient matter. Accordingly Donat recognises two types of oligotrophic waters, produced by geomorphic

and physiological conditions respectively (28). The plankton of the former would resemble that of the eutrophic type, but would be very much less developed in quantity. The geomorphic oligotrophic type may pass over to the eutrophic type as organic matter slowly collects in it or is artificially supplied to it as for instance by the discharge of sewage effluent.

As most lakes are not uniformly deep, but always possess a littoral zone, either scanty or extensive, it is worth while studying the littoral flora and its effect on the character of the lake as a whole. The littoral zone, being shallow, gets enough light, air, and heat, and so becomes rich in vegetation, provided there is sufficient nutrient material available. The surplus of its algal population passes over into deeper waters and affects the character of the whole lake. Shallow pools and ponds will have nearly the same characteristics as those of littoral shelves of lakes, and therefore show development of similar aquatic communities as the latter. In the case of lakes, however, there may be some forms which spend a part of their life-history in the littoral zone and another part of it in deep waters or even at the bottom of the lake. Moreover, in the case of shallow ponds, since there is no definite inflow, the quality of its algal population is more a matter of chance, because it is determined by such factors as wind, wading birds and insects and occasional introduction of the soil algæ of the neighbourhood by rain or flood. The time of introduction of a foreign alga would also determine whether or not it would succeed in competition with the vegetation already present in the pond.

The algæ of the littoral zone of the lakes, and those of the ponds and pools mostly reproduce themselves by zoospores and are, therefore, epiphytic in the first stages of their development. Their early growth is then dependent on the presence of suitable substrata. Of course, other methods of reproduction, namely, by aplanospores, akinetes, zygotes, etc., may, however, be employed, but whenever reproduction takes place by zoospores it would involve an early epiphytic condition. The various kinds of substrata seem to have a qualitative and quantitative effect on the epiphytes growing on them. In general, epiphytes develop much more on dead than on living substrata. As an example of qualitative difference Willer mentions that in Müggelsee, stones had a nearly pure growth of *Epithemia zebra*, while submerged plants had very few of these diatoms growing on them (108). Similarly *Cladophora* was found by him to grow on stones and wood much more abundantly than on submerged plants. This may be due to the fact that living substrata may change the hydrogen-ion concentration appreciably because of the withdrawal of CO_2 from the water when it is assimilating or to the probable influence of nutritive substances diffusing from out of the substratum; it is generally observed that dead or dying parts of filamentous algæ are more

easily colonised than the vigorously living ones. With regard to the type of surface on which epiphytes settle down, it has been observed that *Cladophora*, *Vaucheria*, *Oedogonium* are readily colonised by epiphytes, while most members of the Zygnemales do not afford a good settling substratum to the epiphytes because of their mucilaginous layer (65).

The intensity of light has a great influence on the epiphytic growth. It decreases with the depth of the water and thus a marked zonation is produced. It has been found that different algæ can exist at different depths, for instance, *Amphora ovalis*, *Nitzschia communis*, *N. paleæ* thrive quite well at a depth of 30 meters, while *Cladophora crispata* and *Navicula vulgare* are not found below 5 metres (78). A zonation of algal flora may thus be produced. Local shading of the banks or the presence of submerged macrophytes may, however, restrict the various algæ to higher levels than their normal ones.

In very deep layers the algæ have very feeble light available for photosynthesis and therefore must possess a very low compensation point, i.e. the point at which photosynthesis and respiration compensate one another. The rate of respiration is also low and the chromatophores are deeply pigmented, red-brown or blue-green.

(3) The influence of hydrogen-ion concentration on the distribution of algæ has also been investigated to some extent. Some forms are distinctive of waters which are poor in mineral salts and rich in acids, while others are found mostly in alkaline waters. A majority of algæ, however, can exist under a wide range of hydrogen-ion concentration, although showing their optimum development within a limited range only. A connection between pH and the termination of the vegetative period has been suggested by Ulehla who found that in *Cladophora* while the pH for growth-optimum is 7.7-7.9, at 7.2 growth ceases and zoospore-formation takes place (99). In *Spirogyra* the growth-optimum is at 7.2, while zygote-formation commences at 7.7-7.9. Very few relations between the oligotrophic and eutrophic types of water and the hydrogen-ion concentration have been so far brought out. The shallow eutrophic waters show greater variations in pH than those of deep lakes, on account of greater plankton productivity. pH has also an indirect effect on the iron-content, since with increasing acidity more iron compounds will be dissolved out of the substratum. Thus the iron-content of the water may be a limiting factor, and the results ascribed to change of pH may be really due to iron-content (42a).

(4) The surroundings of a water have some effect on sit algal population and some such instances may be considered here. The presence of woods, plantations or cultivations develop a number of algæ which finally find their way into the lake after a good shower of rain. Thus the type of algal vegeta-

tion would be determined largely by the kind of algæ it receives from the neighbourhood. Wind also helps in disseminating spores, etc., from the neighbourhood. Strong wind helps in aerating shallow pieces of water.

So far I have considered the communities of freshwater algæ living in standing waters only. In flowing waters only the attached forms and the plankton are found. The factor of floating macrophytes is eliminated, but the new factor of the continuous movement of the water is introduced. As a result of the latter the organs of attachment become well-developed in many cases.

After the aquatic algæ come the subaerial ones as next in importance. It must, however, be remembered that there is no absolute line of demarcation between aquatic and subaerial algæ, although the extreme types are fairly well defined. The algæ which inhabit dripping rocks form a connecting link between the subaerial and aquatic types, and include mostly the Myxophyceæ and certain Diatoms. Abundant aeration and periodical spells of dessication form the chief characteristics of subaerial algæ. These live on soil, barks of trees, wooden palings, damp walls, etc. The soil algæ may be subterranean or surface-inhabiting. The subterranean forms do not have to withstand such extreme dessication as the surface-forms and are, as a rule, smaller in size than the latter. Many of the subterranean forms, such as the soil Diatoms, possess a means of slow locomotion, so as to enable them to seek out places of best moisture in dry weather. Blue-green algæ can exist in deeper layers of soil than the green algæ or the Diatoms, because they are able to grow in relatively weak light. The subterranean algæ will be influenced by the phanerogamic flora of the soil also, because the excretions and decay-products of the roots of the latter will have some effect on the former.

A number of interesting things characterise the surface-inhabiting algæ, as most of them occur in rather dry and exposed places. In the first place, they may assume various colours, like orange-yellow in *Trentepohlias*, purple in *Zygogonium ericetorum* and brown in many Myxophyceæ. Secondly, their ordinary vegetative cells have power to endure prolonged drought without any noticeable outward change and to revive in a very short space of time on again getting favourable conditions. Fritsch has given a probable explanation for this power of the surface-algæ to withstand dessication without undergoing much change of form (38). The hygroscopic nature of the alga enables it to take up moisture when the atmospheric humidity is high, as for instance in the night, and to part with it when it is low. This results in intensive metabolism and growth during moist periods and rest during dry ones. The cells of these algæ have few or no vacuoles so that the cytoplasm is in close contact with the cell-wall, and any moisture absorbed

is rapidly taken in. The protoplasts have the power of retaining moisture during dry weather. This is probably due to the fact that in most surface algæ the cell contains certain granules—fat, cyanophycin, etc.—which are used by it for the manufacture of additional osmotic material, thus preventing the exit of moisture from the protoplast. It would seem, therefore, that in a spell of dry weather the cells lie in a sort of resting condition, which consists of the formation of additional osmotic substances inside the cell making it practically impermeable. No external change like the thickening of the wall, for instance, is therefore necessary. Plasmolysis by osmotic solutions like the saline is more difficult in these than in aquatic algæ and also recovery from plasmolysis while inside the saline solution is more rapid (38). This latter power of recovery from plasmolysis is also found in marine algæ. It is not surprising, therefore, that a number of marine forms like *Plectonema battersii* and *Rhizoclonium riparium* are also found occurring in the soil (38).

Because of their power of withstanding drought the terrestrial algæ play a very important rôle in colonisation of inhospitable strata. They are able to settle down on exposed surfaces, even though the latter be smooth and vertical, possibly because of the presence of mucilage in most of them. After some time the surface becomes fairly eroded and a certain amount of humus collects there because of the decay of some of these algæ. This forms a substratum upon which the spores and seeds of other plants can easily germinate. The presence of mucilage in many of these terrestrial algæ helps to retain moisture, which is necessary for the germination of these spores and seeds.

From the above considerations it will be clearly seen that the terrestrial alga has a wide importance in the economy of nature. Further research into its ecology is bound to be very paying.

The ecological aspect of the study of algæ has practically been neglected in India. With the exception of very few papers nothing has been published so far on the ecology of Indian algæ. Biswas has described some subaerial algæ of Barkuda Island and some forms inhabiting the Salt Lakes, Calcutta (3, 4). Handa and myself have also described some subaerial forms from Burma (60, 53). Chaudhuri and Akhtar have published a paper on an alga inhabiting Cycadales (16). For some time I have been engaged in studying the algæ inhabiting the streams and ponds in the Khewra Salt Range, and the Salt Lake, Sambhar (Rajputana), and it is hoped that very interesting results will follow. Species of *Anabaena* and *Arthrospira* have been found to be flourishing at a density of 15°B., and a *Chlamydomonad* at such a high density as 27°B. Considering that the average density of sea-water is about 3°B., and the

saturation point of salt is 25°B., the above observation is very interesting indeed.

A few instructive papers on the ecology of algæ from abroad may be profitably mentioned here. Fritsch has written very useful and concise papers on terrestrial and encrusting algæ (38, 41). Ercegovic's paper on some lithophytic Cyanophyceæ and that of Taylor on the Alpine algal flora of British Columbia may be mentioned here (30, 95a). Cholnoky has described symbiosis in Diatoms, while Hegner has found *Euglena* inside tadpoles and Langer on some Oscillariæ as parasites in human intestine (21, 63, 68).

CYTOLOGICAL.

Recently the question as to whether or not the Golgi bodies and Mitochondria are represented in plants, and if they are, in what way, has become very prominent. Bowen has described certain bodies, which he named 'osmiophilic platelets' in the male heads of some species of *Polytrichum* and in the root-tips of *Equisetum arvense*, *Vicia faba*, etc. (12). According to him these 'platelets' represent the Golgi material of the plant cell. Patten, Scott and Gatenby have in a large measure confirmed Bowen's findings and claimed that the 'platelets' closely resembled the Golgi bodies of the Hemiptera among animals (82). Dangeard, however, believes that the vacuolar system of the plant-cell or the vacuome represents the Golgi elements of the animal-cell (27). This view has been enthusiastically supported by Guilliermond (57). These two workers have found in the Cyanophyceæ and Bacteria certain capsules which stain deeply with aniline dyes. Similar bodies found in the fungi were always located in the vacuoles. Most of the work in this connection has been done on higher plants. Investigation of algæ from this point of view is likely to be very interesting and profitable.

A number of cytological studies have been made on the various groups of algæ lately, and they may just be referred to here. Cholnoky and Geitler have dealt with Diatoms (17, 48, 49); Lee and Poljansky with Cyanophyceæ (86, 69); Carter, Mundie, Ohashi, Spessard, Wesley, and Ferguson with Chlorophyceæ (15, 75, 79, 94, 104, 30a), while special cell-organs like pyrenoids and eye-spots have formed the subjects of papers by Geitler and Mast respectively (46, 47, 73).

DEVELOPMENTAL.

Under this heading I wish to mention some of the recent researches on reproduction and the various developmental stages in the life-history of algæ. Auxospore-formation in Diatoms has been described by Cholnoky (18, 20); and conjugation and zygote-formation of the Conjugatæ have engaged

the attention of Czurda, Cholnoky, Magdeburg, Scherfell, and Saunders (25, 72, 19, 89, 88). Crow has studied the formation of colonies in Chlamydomonadales and Cyanophyceæ (22, 23, 24). Fritsch has published a paper on the developmental stages in Desmids (42). Lander has described oogenesis and fertilisation in Volvox (67). The papers by Entz on cyst-formation in freshwater *Ceratium*, and Wesley on asexual reproduction in *Coleochaete* may well be mentioned here (29, 103). From our country, Handa has published a paper on the Akinetes in *Oedogonium*, and myself on a curious method of reproduction in an aquatic species of *Anabaena* (61, 54).

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APPLIED.

In this part of my address I wish to discuss some of the ways in which the study of algæ can be made use of in our everyday life. The foremost of these is in connection with fish-culture. The abundance and quality of fish in any piece of water is definitely related to the abundance and quality of the microscopic life present in it. In most cases the food of fish consists of microscopic animals like the Crustacea, rotifers, insect-larvæ, etc.* Some smaller fish may devour even algæ, for instance the gizzard-shad, the algal food of which has been studied by Tiffany (97, 98). The microscopic animals depend for their food on microscopic plants, most of which are algæ. The latter when alive may be devoured by the former and when dead form fine organic detritus which constitutes the chief food of zooplankton. It is clear, therefore, that the presence of algæ is very necessary for the production of fish in any piece of water. The algæ are the producers of food and the microscopic animals are its consumers, and the number of consumers naturally depends on the number of producers. The microscopic life varies in different kinds of waters with regard to abundance and the kind of organisms; also variation occurs in different times of the year. Broadly speaking, the quality and quantity of the dominant algæ is dependent on the physical and chemical features of the lake or pond, and it has been found that it goes hand in hand with the quality and quantity of the dominant fish. Unfortunately we have very little knowledge as to the nature of the food of smaller aquatic animals or even of many common fish. It would be, therefore, very helpful indeed, if correlation between the various kinds of algæ and the different types of fish found in our fisheries were worked out. As far as I am aware, none of the fisheries in India belonging to Government or to private individuals have ever made any attempt to do it. It is high time that such investigations should be undertaken. It is curious that in India in the Fishery Departments not a single algologist is employed. It may be so because very little research is ordinarily done in

these departments and most of them act merely as agents to issue licenses to fishermen and anglers. But it must be remembered that just as scientific study of agriculture has led to better yield of crops per acre so scientific investigation of freshwater life will lead to better yield of fish. It may be admitted that in some cases data as to the direct food of certain fish have been collected but the nature of nutriment upon which their prey in its turn relies for sustenance has not been worked out. Fish-breeding is bound to profit from a more adequate knowledge of aquatic biology. Investigations on the various chemical and physical features of different waters and their algal population will help to determine the quality and abundance of its microscopic animal-population and thus control the nature and extent of its fish-life. In support of this statement a few facts which have been so far discovered in other countries may be mentioned here. Oligotrophic ponds which are characterised by having green phytoplankton have Cladocera and no Rotifers, while eutrophic ones which have mainly blue-green algæ harbour many Rotifers, abundant *Cyclops* and less Cladocera (42a, p. 235). In dystrophic type, which is deficient in mineral nutriment but has an abundance of foreign organic matter, fauna is poorly developed (42a, p. 237). Again, it has been observed that while Crustacea and insect-larvæ will devour any algæ Rotifers and ephemerid larvæ exercise some degree of selection (42a, p. 254). It has also been observed that in England near factories, due to the effect of water-pollution on microscopic life, death of the inhabiting fish has been caused. Again, it has been noticed that in England the produce of Salmon Fisheries varies from year to year. The cause has not yet been found, but most probably it lies in the earliest stages of the life of the fish (35, p. 19). These known facts are very scanty and have been obtained outside India. A thorough research into the relation that exists between algæ and fish is very badly needed in our country and I am sure it will be very paying if it is ever undertaken.

Freshwater Biological Stations have been established in many countries, where such investigations are made; for instance, at Plön in Germany, Lunz in Austria, Aneboda in Sweden, and Lake Balata in Hungary. In Ireland during the war, when fish supply was becoming scarce, a laboratory was established on the River Shannon, where investigations on the occurrence and distribution of microscopic life were carried on, and there is a strong move at present to establish a Freshwater Biological Station in the English Lake District. Dr. E. S. Russel, while speaking at a meeting of the Freshwater Biological Association of the British Empire which was held to consider the desirability of establishing the above-named station, remarked that in Colonies and Dominions there was a great field for development of Freshwater Fisheries (35, p. 22).

It is difficult to cope with the sea, but lakes and rivers can be controlled and made to yield much more fish than they do at present by a little scientific study of the habits and food of the latter. I venture to suggest, therefore, that it would be very profitable if every inland Fishery Department of India maintained a Research Laboratory and a staff consisting of trained chemists, zoologists, and algologists, as is done in all civilised countries.

The second use of algological study to which I shall refer is in connection with agriculture. It is known that cultivated soils harbour a great diversity of algæ, especially unicellular and colonial. They must have some effect on the crop. Should they be encouraged to grow in the fields or should they be cleared out? Many scientists suspect that Green Algæ are able to fix atmospheric Nitrogen (38, p. 224). If it is proved to be correct then certainly soil-algæ should be encouraged to grow in the fields, as they would increase the nitrogenous material found in them. Even if algæ are found to be incapable of fixing atmospheric Nitrogen, their presence will increase the fertility of the soil, because their decaying bodies and the mucilage which most of them produce will add to the organic content of the soil. These algæ are rather hardy and are able to thrive in comparatively poor and dry soil. Moreover, a curious instance in which algæ are actually used as manure has come in my own observation. At the Sambhar Lake, Rajputana, a number of algæ are developed in the water of the lake, reservoirs and pans. When the density of the water becomes high due to evaporation these algæ are mostly brought up to the surface and collect on one side due to the action of the wind. They are then skimmed off and yearly something like a thousand cartloads of them are taken away by the villagers and used as manure, as they are very rich in nitrogenous material. I do not know if there are other places in India where algæ are produced in sufficient quantities to be collected and used as manure, but I venture to think that it is possible that in many inland waters algæ could be cultivated to such an extent with comparative ease and at a very little cost as to yield sufficient amount of good manure. According to Prosper characeous deposits are collected in Switzerland from lakes and pools and used as manure. Moreover, the peculiar odour emitted by them is said to help in keeping the soil from insects (85).

The third practical use of the study of algæ is in connection with public health. All the important cities of the civilised world maintain waterworks for the supply of water for drinking and other purposes. This water is generally stored in large tanks or reservoirs and must necessarily be as pure as possible. Unfortunately, in many cases algæ and bacteria develop in these tanks and unless they are removed the water becomes unfit

for use. In simple cases it may acquire only bad taste and smell, while in extreme cases it may cause an epidemic of some disease. The unchecked growth of algæ produces sufficient amount of organic material to enable bacteria to flourish in the water as their dead or decaying bodies provide food to the latter. It is necessary, therefore, that the physical and chemical conditions of every tank and the nature of its algal population should be determined, and, if possible, measures should be used to check the growth of algæ or to eliminate them altogether. In this connection at least one example can be given from India. The Calcutta Corporation has asked Mr. K. Biswas of the Royal Botanic Gardens, who has studied a large number of algæ from many places, to deal with this problem of eliminating algæ from their waterworks (34). I would like to see our young trained algologists employed for similar work in waterworks of our other great cities.

Another aspect of the study of algæ with regard to its bearing on public health is the relation of algæ to the larvæ of disease-producing insects like the mosquito for instance. The larvæ depend on algæ for their food; consequently, if the algæ on which they feed are determined and killed, the number of larvæ and hence that of mosquitoes, will be considerably decreased. Howland has recently published a paper on the bionomical investigation of English mosquito-larvæ, with special reference to their algal food (64). In our malaria-ridden country investigations of this type would be of great public use. Moreover, there is probably a further connection between some algæ and the mosquito-larvæ. In 1923, Vasconcelos drew attention to certain species of *Chara* which seemed to cause the death of mosquito-larvæ by a poison which the latter obtained by feeding on them (100). In 1928, Messrs. Mathesan and Hinman published a paper on their observations on *Chara fragilis* in connection with mosquito and asserted that the plant growing in still and running water aquaria of various kinds prevented mosquito breeding (74). When the plant was decaying normal development of the larvæ took place, but when the plant recovered the larval growth was inhibited. Experiments on this alleged larvicidal property of the species of *Chara* have been recently made by Mr. Pal of Burma, Mr. Blow of England, and Dr. Hamlyn-Harris of Australia (81, 9). These three workers seem to have got negative results. It is very desirable, therefore, that experiments should be made in our country, and the question of the larvicidal property of *Chara* species be finally settled, at least as far as India is concerned.

The last practical use of the study of algæ to which I shall refer is in connection with industries. Many algæ produce mucilage quite freely and this mucilage is, I understand, being used by some Germans for purification of oils. In the Panjab

University Chemical Laboratory, Dr. Sarin is making experiments on the subject, and we are looking forward to the publication of his results.

Another instance in which knowledge of algæ is likely to be very helpful from the industrial point of view is in connection with salt manufacture at Sambhar Lake, Rajputana. As I have mentioned above, species of *Anabaena*, *Arthrospira*, and *Chlamydomonas* live abundantly in the water of the lake, reservoirs, and pans, and some of them remain alive and healthy even at the density when salt is crystallising. The presence of these algæ interferes with the evaporation of water and also with the sucking in of salt from the soil, as they may form a layer at the bottom. Moreover, bacteria develop due to the presence of the dead bodies of these algæ and the brine gets coloured pink or red in the final stages so that the salt that is produced is not pure white in colour and does not crystallise well also. Thus the market value of the salt produced under these circumstances decreases. The problem of the elimination of these algæ is at present engaging the attention of the Salt Department; the algal flora of the lake is being studied and experiments on the effect of various chemicals on it are being devised and carried out.

CONCLUSION.

In conclusion, ladies and gentlemen, I thank you for the patient hearing that you have given me. If this address succeeds in arousing a wider interest in the lowly group of algæ and in instigating some of you to take up any aspect of the study of Indian Algæ for research, it will have achieved its purpose.

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Section of Botany.

Abstracts.

ALGÆ.

1. The *Volvox* of Poona.

D. L. DIXIT and V. V. APTE, Poona.

Excepting the ecological observations on Volvocales by Prof. Iyengar of Madras no work has been done in India on that group. Unlike Madras, Poona and Bombay side seems to be quite favourable particularly for *Volvox*. The observations on this form could be summarised as follows :—

(i) *Volvox* under consideration is a perfectly hollow oblong individual with only one cell thick peripheral wall surrounding a cavity filled with fluid. (ii) There is a regular polarity which is evident, by the distribution of the cells, by the occurrence of the red eye spot and by the restricted presence of the sexual and asexual bodies to the hinder part. (iii) A complete study regarding the size of the colony, the number of the cells in the colony with the detailed study of the cell and its wall and the complicated structure of the protoplasmic strands has been worked out. (iv) Observations regarding the formation of the daughter colonies have been made. The invagination stage described by Pascher, Oltmanns and others could not be seen. (v) No traces of either the grand-daughter colonies or the initials of sexual reproductive cells could be observed. (vi) The formation of the oogonia is very peculiar especially as it involves the absorption of nutritive material from the neighbouring cells. (vii) As regards fertilisation divergent views are expressed but we are inclined to hold that self-fertilisation probably occurs. (viii) The *Volvox* under consideration is distinctly a *globator* form, but it does not exactly resemble any of the four forms described under *globator* by Pascher (Süsswasserflora-Heft 4) and so deserves special mention.

Lastly the authors are inclined to believe on substantial grounds discussed in the paper that *Volvox* should be regarded as an individual plant and not a colony or cœnobium.

2. A contribution to our knowledge of the algal flora of Lahore soils.

H. D. SINGH, Lahore.

Fifteen soil samples have been studied. Four species of green algæ, 12 species of Diatoms and as many as 28 species of blue-green algæ have been found and described. Isolations were made both in agar media as well as in liquid media. Only 3 species grew in solid media. A comparative study of the algal flora of the fresh soils and the same soils desiccated for 12 weeks was made. No appreciable difference in the algal content was found. The following genera were found :—*Pleurococcus*, *Chlorococcum*, *Ulothrix*, *Hormidium*, *Aphanotheca*, *Eucapsis*, *Aphanocapsa*, *Chroococcus*, *Oscillatoria*, *Isocystis*, *Phormidium*, *Nostoc*, *Anabaena*, *Cylindropspermum*, *Scytonema*, *Calothrix*, *Hapalosiphon*, *Fischerella*.

Cyclotella, *Synedra*, *Navicula*, *Gyrosigma*, *Amphora*, *Cymbella*, *Rhopalodia*, and *Nitzschia*.

3. A contribution to our knowledge of the Diatomaceæ of the Punjab. II.

S. L. GHOSE and A. MAJID, Lahore.

The systematic study of the Diatoms inhabiting soil and freshwater in the Punjab is being continued. A fresh collection was made from Lahore and Simla districts.

More species of *Navicula*, *Gomphonema*, and *Nitzschia* are added to the list.

4. A contribution to our knowledge of the unicellular Chlorophyceæ and Flagellates of the Punjab.

S. L. GHOSE and RAGHUNATH DAS, Lahore.

In this paper 68 species of unicellular Chlorophyceæ, and Flagellates, belonging to the following 31 genera are described:—

Chlamydomonas, *Gonium*, *Pandorina*, *Eudorina*, *Pleodorina*, *Carteria*, *Sphaerella*, *Phacotus*, *Coccomyxa*, *Gloeocystis*, *Characium*, *Protosiphon*, *Pediastrum*, *Hydrodictyon*, *Oocystis*, *Nephrocystium*, *Ankistrodesmus*, *Actinastrum*, *Kirchineriella*, *Scenedesmus*, *Coelastrum*, *Pleurococcus*, *Olosterium*, *Cosmarium*, *Dicidium*, *Euastrum*, *Staurastrum*, *Chlorobotrys*, *Euglena*, *Phacus*, and *Trachelmonas*.

FUNGI, BACTERIA, LICHENS.

5. Theories of sex in fungi.

S. R. BOSE, Calcutta.

Current theories of sex in fungi are reviewed from Blakeslee's heterothallism based on bisexuality in 1904 down to Gwynne Vaughan's nutritive heterothallism in 1930, Hartmann's theory of relative sexuality in 1931 and Ames's idea of hermaphroditic self-sterile strains (potential bisexuality) in 1932.

From a survey of all these theories the idea of potential bisexuality—hermaphroditic self-sterile strains—advanced by Ames seems very striking, although it has similarities with Hartmann's theory of relative sexuality and Brunswik's hypothesis of heterothallism based on one or more self-sterility factors. In the present state of knowledge, however, it is too early to form any decisive opinion.

The author's work with a large number of monosporous cultures and pairings of a number of two monosporous cultures of *Polyporus ostreiformis* Berk. and *Polystictus hirsutus* Fr. carried over for a period of about three years shows that both the species are strictly heterothallic and bisexual. These two sexes seemed absolutely stable as they could not be changed by different external conditions nor by different kinds of media; in this respect *Polypores* would seem to resemble higher animals.

6. *Grammothele reflexa*,—a new species of Hydnaceæ from Bengal.

S. P. AGHARKAR and S. N. BANERJEE, Calcutta.

This species has been collected by the writers during the months of July to October, 1931-32 from Calcutta and suburbs. It occurs fairly commonly on logs and posts mainly of Sāl and Teak forming more or less small orbicular patches. It differs from other species of *Grammothele* in having the pileus reflexed owing to which it has been named '*reflexa*'. The writers express their indebtedness to Dr. E. A. Burt of the Missouri Botanical Gardens, who after careful examination confirmed it as a new species. Detailed morphological and anatomical descriptions have been given in this paper.

7. Some Hymenomycetous Fungi from Calcutta and suburbs.

S. P. AGHARKAR and S. N. BANERJEE, Calcutta.

In this paper a systematic account of all the species under consideration is given in detail. The following species have been collected during the months of July–October, 1930–32, and of these, those marked with (*) have been recorded for the first time from Bengal and those marked with (†) from India :—

CLAVARIACEÆ :

- †1. *Clavaria angulispora* Pat.
- †2. *Clavaria compressa* Schw.
- †3. *Clavaria pulchra* Peck.
- †4. *Clavaria laticolor* B and C.
- †5. *Clavaria* sp. (No. 9).
- †6. *Cloveria* sp. (No. 10).
- †7. *Lachnocladium* sp. (No. 11).
- †8. *Lachnocladium brasiliense* Lév.

HYDNACEÆ :

- †9. *Grammothele* *reflexa* Agharkar and Banerjee, n. sp.
- †10. *Grammothele* *cineracea* Bres.
- 11. *Irpea flavus* Kl.
- 12. *Hydnum* *pulcherrimum* Berk. and Curtis.

CALOCERACEÆ :

- †13. *Dacryomitria glossoides* (Pers.) Bref.
- †14. *Calocera cornea* Fr.
- †15. *Calocera striata* (Hoffm.) Fr.

AURICULARIACEÆ :

- †16. *Auricula tenuis* (Lév.) Farl.
- 17. *Auricularia auricula*—Judæ (L.) Schroet.
- 18. *Auricularia rugosissima* (Lév.) Bres.
- *19. *Auricularia polytricha* (Mont.) Pat.

TREMELLACEÆ :

- 20. *Tremella fuciformis* Berk.
- 21. *Guepinia soathularia* (Schw.) Fr.
- 22. *Guepinia ramosa* Curr.

8. Comparative anatomy of Bengal species of Thelephoraceæ.

S. N. BANERJEE, Calcutta.

In the present paper the writer has given a comparative account of the anatomical structure of the fruit-bodies of the different species of Thelephoraceæ of Bengal. The different types of basidia, spores, cystidia, setæ, gleocystidia, paraphyses, lactiferous cells, vesicular cells, and hyphal pegs have been taken into consideration. Special stress has been laid on the hyphal system composing the fruit-bodies and it has been generally found that in most cases two to three different types of hyphæ, viz. skeletal, generative and binding are present. Generative hyphæ are not always associated with clamp-connections. H-connections have been observed in a few cases. According to the types of hyphæ present, the species have been classed under dimitic and trimitic following Mr. Corner.

9. Thelephoraceæ of Bengal—I.

S. N. BANERJEE, Calcutta.

This paper forms the first contribution to the knowledge of Bengal Thelephoraceæ. Very little attention has been paid to this group of fungi and from Butler's list of Fungi of India it has been found that only nine Bengal species have been reported to date. With a view to write a monograph of this group attempts are being made to collect materials from different parts of the province.

In the present paper thirty-five species have been included belonging to six genera, viz. *Stereum*, *Hymenochaete*, *Craterellus*, *Asterostremella*, *Corticium*, and *Aleurodiscus*. Most of these species have been collected

from Calcutta and suburbs during the months of July to November, 1930-32. A detailed systematic account of all the species under consideration has been given and an analytical key has been proposed for the determination of the species of *Stereum* and *Hymenochaete* concerned. The determination of the species of *Corticium* and *Aleurediscus* is extremely difficult without proper literature on tropical species and has been left over to be completed whenever possible. In the following list those marked with (*) have been recorded for the first time from Bengal and those marked with (†) from India :--

- | | |
|---|---|
| *1. <i>Stereum scytale</i> Berk. | *17. <i>Stereum annosum</i> B. and Br. |
| *2. <i>Stereum nitidulum</i> Berk. | †18. <i>Stereum fissum</i> Berk. |
| 3. <i>Stereum fuscum</i> (Schräd.) Quel. | 19. <i>Stereum purpureum</i> Pers. |
| †4. <i>Stereum umbrinum</i> Berk. and Curtis. | †20. <i>Stereum</i> sp. (No. 13). |
| †5. <i>Stereum vibrans</i> Berk. and Curtis. | *21. <i>Hymenochaete cacae</i> Berk. |
| *6. <i>Stereum endocrocinum</i> Berk. | *22. <i>Hymenochaete rubiginosa</i> (Dicks.) Lév. |
| 7. <i>Stereum hirsutum</i> (Willd.) Fr. | †23. <i>Hymenochaete aspera</i> Berk. and Curtis. |
| *8. <i>Stereum fasciatum</i> Schw. | 24. <i>Hymenochaete tenuissima</i> Berk. |
| *9. <i>Stereum lobatum</i> (Kunze) Fr. | *25. <i>Hymenochaete nigricans</i> (Lév.) Bres. |
| †10. <i>Stereum petalodes</i> Berk. | †26. <i>Asterostremella rhodosporea</i> Wakefield. |
| †11. <i>Stereum crenatum</i> Lév. | †27. <i>Craterellus cornucopoides</i> (Linn.) Pers. |
| *12. <i>Stereum percome</i> Berk. and Curtis. | 28-33. <i>Corticium</i> sp. (Nos. 21, 36, 45-48). |
| 13. <i>Stereum papirinum</i> Mont. | 34-35. <i>Aleurediscus</i> sp. (Nos. 11 and 14). |
| *14. <i>Stereum elegans</i> Fr. | |
| 15. <i>Stereum alternum</i> Lloyd. | |
| 16. <i>Stereum Schomburgkii</i> Berk. | |

10. A contribution to our knowledge of coprophilous fungi.

N. A. MAHJU, Lahore.

Dungs of only six animals, viz. rabbit, sambar, horse, goat, buffalo, and sheep have been studied thoroughly for coprophilous fungi. Altogether 29 different species in 21 genera have been recorded. These are :—*Mucor mucedo* ; *Pilobolus longipes*, *P. minutus*, *P. crystallinus* ; *Aspergillus flavus* ; *Myxotrichum charatum*, *M. aeruginosum* ; *Magnusia nitida* ; *Sordaria macrospora*, *S. curvula* ; *Chaetomium spirale* ; *Sporormiella nigropurpurea* ; *Pezolepsis* sp. ; *Ascobolus viridis* ; *Lasibolus hirtellus* ; *Lachnella fraxinicola*, *L. albido-fusca* ; *Coprinus nivenus*, *C. papillatus*, *C. radiatus*, *C. ephemerus* ; *Bolbitus vitellinus* ; *Dendrostilbella byssina* ; *Silicopodium sanguineum* ; *Oedocephalum glomerulosum*, *Arthrobotrys superba* ; *Stysanus stemonites* ; *Torula convoluta* ; *Isaria brachiata*.

11. Some diseases of the pomegranates.

JAGTAR SINGH, Lahore.

Diseases of the pomegranate due to *Pyrenochaeta* sp. and *Amphi-chæta* sp. have been studied. The causal organisms were isolated and cultural studies made. Effects of various factors on growth have been studied and successful inoculation experiments showing the pathogenicity of the two fungi made.

12. Effect of X-rays of fungi.

JAGTAR SINGH, Lahore.

Young colonies of *Gloeosporium* sp. were irradiated both to soft and hard X-rays, exposures ranging from one second to six minutes and it was found that they had a stunting effect upon the vegetative growth and a stimulating effect on the production of acervuli.

13. Die-back and Anthracnoses of chillies.

D. K. JHINGAN, Lahore.

Three parasitic organisms, viz. a *Vermicularia*, a *Colletotrichum*, and a *Gloeosporium* have been isolated and their growth under various physiological conditions studied. A large number of plants have been successfully inoculated and their pathogenicity established. Saltants were regularly produced by *Gloeosporium* when grown in Czapek's medium.

14. Diseases of Kashmir apples.

PUSHKAR NATH, Lahore.

Seven diseases of the Kashmir apples have been studied. These are apple leaf spot caused by a *Phomaceous fungus*, apple rot caused by *Mycelia sterilia*, apple scab caused by *Fusicladium dendritichum*, apple rot caused by *Penicillium* sp., pink rot of apple caused by *Cephalothecium roseum*, leaf spot caused by *Cladosporium* sp., and apple rot caused by *Aspergillus* sp. Isolation of the causal organisms were made in every case, their growth in culture studied and by successful inoculation experiments, their pathogenicity has been established.

15. On *Sclerotium oryzae*—a Sclerotial disease of the rice in the Punjab.

PUSHKAR NATH, Lahore.

Isolation of the causal organism was made and seedlings of rice grown in test tubes were successfully inoculated. Sclerotia were not only formed at the base of the stem and leafy sheath but all along the roots. Pycnospores were formed in a few cases. Growth of the fungus under different physiological conditions has been studied.

16. A short note on the so-called bacterial disease of the wheat in the Punjab.

H. CHAUDHURI, Punjab.

Hutchinson's work on *Pseudomonas tritici* on wheat and Milne's on ear-cockle on wheat are similar regarding the external appearance of the plants after infection. In both cases gummy exudations due to bacteria are seen. Writer found the so-called bacterial disease, appearing at Multan in a serious form last February and also received a packet of infected material from Milne. The former shows characteristic symptoms of Hutchinson's *Ps. tritici*, though in a few cases the nematodes could be found in the growing region, and Milne's material was full of ear-cockles with the inflorescences covered by gummy exudations. Isolations were made and this paper deals with the result of inoculation of pure cultures.

17. The endotrophic fungus in *Petalophyllum indicum* Kash.

H. CHAUDHURI and BHAGAT RAM, Lahore.

Endotrophic fungus is regularly found in *P. indicum*. The fungus has been isolated and cultural work done. The paper deals with the relationship of the fungus with the host.

18. A brief review on the various diseases of bananas (plantation and storage) as occurring in the College Plantation with the practical method of control of the most important ones.

B. CHONA, Lyallpur.

There was a serious outbreak of disease, almost in an epidemic form, this summer in the Banana Plantation of the Punjab Agricultural College, Lyallpur. Hardly any 'Bunch' could be cured properly or free from disease. Moreover the new suckers planted failed to crop up because of the severe attack of the disease. The causal organisms have been isolated and studied particularly from the pathological point of view. Some methods of practical control have been brought out to keep the disease in control and not allow it to become a limiting factor in 'Curing' of fruit and healthy propagation of suckers.

19. Storage rot of potatoes due to a species of *Fusarium*.

B. CHONA, Lyallpur.

Heavy losses of stored potatoes in summer months are commonly met with in every potato-growing area. This has been ascribed in the present case to the activity of a *Fusarium* sp. Cultural and pathogenic study of the causal organism is dealt with in this paper. A few useful hints for practical control of the disease have been evolved.

20. A short note on the fungi found on different species of Citrus in the Punjab.

H. CHAUDHURI, Lahore.

In connection with the 'wither-tip' investigation the writer has collected about 20 genera of fungi. Some of them are saprophytic. These are being studied in detail. A list of 20 genera is given.

BRYOPHYTA.

21. On the structure of an Indian moss, *Physcomitrellopsis* sp. from Benares.

K. M. GUPTA, Lucknow.

The material was collected and fixed in chrom. acetic acid by Prof. B. Sahni at Benares in 1919 and was given to the author for description.

The plant grows in tufts of green on damp ground. The perichaetial leaves are large and completely surround the sex organs and sporogonium. The plant is monocious and bears on one and the same head antheridia and archegonia intermixed with two kinds of paraphyses, one club-shaped and the other capitate.

The sporogonium with its characteristic mitriform, deeply lobed calyptra is deeply immersed in the tip of the stem which closely envelopes it. There is a distinct line of dehiscence, composed of smaller cells with lower walls thickened, along which the sporogonium wall ruptures. The upper part of the capsule is thrown off as an operculum but there is no distinct annulus.

22. Some further notes on the morphology of *Notothylas Levieri* Schiff. MS.

S. K. PANDE, Lucknow.

In an earlier paper (Pande, *On the morphology of N. Levieri*, *Proc. Ind. Sc. Congress, Madras*, 1929), the author described some of the stages in the development of the sex organs and the sporophyte of *N. Levieri*, but for want of suitable material most of the early stages in these important phases of the life-history of this plant could not be followed. Most of these have now been obtained from an investigation of material collected early in the rainy season from several localities in Mussoorie and Nainital, and these are described in this paper.

The species is not dioecious as described by Prof. Kashyap but monoecious and protandrous.

The development of the sexual organs conforms to the usual type found in other species of *Notothylas*.

The youngest embryo seen consists of four cells which arise as a result of two divisions at right angles to each other. Another wall is now laid down at right angles to both of these and produces an eight-celled embryo. Later on the three tiers of the embryo are established.

There is no columella and the archesporium is derived from the whole or the endothecium, while the amphithecium produces the wall alone. The sporogonium dehiscence generally along one suture only and the valves are hygroscopic.

23. Further instances of vegetative propagation in two mosses: one terrestrial and the other epiphytic.

G. P. MAJUMDAR, Calcutta.

The Mosses have been sent to Kew for identification. They were collected in Calcutta during July and August, 1932.

In the first case the reproductive organs are like fruit bodies developed in the axils of vegetative leaves of all the plants growing gregariously on the ground. Each plant bears three or four such bodies on the comparatively long stem at some distance from each other. Each such body consists of two or four special involucreal leaves one embracing the other, and red in colour. Protected by these enveloping leaves are the few slightly curved, club-shaped brood bodies full of starch grains. They are more like the antheridia and are not like the ones described by Goebel in the cases of *Webera erecta* and *Webera annotina*. On germination two leaf-like outgrowths fold over and cover the colourless apical region and form the vegetative bud. Further steps could not be followed.

In the second case no sexual reproduction has been observed, and but for the character of the leaf, which is a typical moss leaf, it would be difficult to say if the plant is not an Acrogynous Jungermanniales. The reproductive organs are borne on the apices of lateral branches. They are cup-shaped just like the involucreal cup at the base of the sporogonium of an Acrogynous Jungermanniales. Each such organ in its turn is surrounded by a whorl of ordinary leaves in the axils of which atrophied archegonia, two in number, have been noticed. In these organs filling the lower portions are innumerable unicellular thick-walled green spore-like bodies are produced. On germination each such body sends out two filaments on opposite sides—one develops into a protonema and the other into a rhizoid.

PTERIDOPHYTES.

24. Notes on vegetative budding in certain Indian ferns.

T. C. N. SINGH, Cuttack.

The types studied include the following four species : *Pteris longifolia* L., *Dryopteris prolifera* (Retz.) C. Chr. (from Pandankot in Rajmahal Hills), *Adiantum caudatum* L. (Nainital Hills), and *Adiantum lunulatum* Burm. (Khandagiri Hills). The anatomical details are given in the full paper.

25. A study of the genus *Lycopodium* in India.

N. P. CHOWDHURY, Lucknow.

This work is chiefly based on some Indian species of *Lycopodium* collected by Prof. M. O. P. Iyengar and others and placed at the author's disposal. The following species were identified by Mr. K. P. Biswas and the authorities of Kew Herbarium :—

- | | |
|---------------------------------|--------------------------------------|
| 1. <i>L. Hamiltonii</i> Spring. | 5. <i>L. phyllanthum</i> Hk. et Arn. |
| 2. <i>L. setaceum</i> Hamilt. | 6. <i>L. Wightianum</i> Wall. |
| 3. <i>L. serratum</i> Thunb. | 7. <i>L. clavatum</i> L. |
| 4. <i>L. Phlegmaria</i> L. | 8. <i>L. cernuum</i> L. |

The genus is studied mainly from the point of view of its distribution, anatomy, modes of vegetative propagation, and epidermal structure. The stele in the first five species is essentially radial with considerable modifications in *L. Phlegmaria* and *L. phyllanthum*. In *L. Wightianum* it is of the so-called 'parallel banded' type. The anatomy of *L. Hamiltonii*, *L. setaceum*, *L. phyllanthum*, and *L. Wightianum* is now, as far as I know, being described for the first time. Intracortical roots have so far been observed by me in *L. Hamiltonii*, *L. setaceum*, *L. phyllanthum*, *L. serratum*, and *L. Phlegmaria* only; in the three first named species they are now recorded for the first time. In one of the roots of *L. Hamiltonii* a ring-shaped xylem with an island of phloem in the centre has been observed. In *L. Phlegmaria* and *L. phyllanthum* large leafy bulbous buds were seen attached near the base of the main stem of the plant. These bulbs seem to be easily separable from the parent plant and are evidently organs of vegetative reproduction. Root tubercles as described by Treub (*Ann. of Bot.* I, 122) were found in *L. cernuum*.

An attempt has also been made to test the systematic value of epidermal characters. The epidermal characters of all the above-mentioned species together with many more from other localities have been investigated. The details such as the orientation and size of the stomata, the sinuosity of the walls, and size of the upper and lower epidermal cells, the structure of the guard cells, the presence or absence of a vestibule and even the presence or absence of stomata on the upper epidermis seem to be of diagnostic value. Further work in this line is in progress.

26. A preliminary report on the fern flora of Calcutta and its suburbs with a note (morphological and anatomical) on the vegetative propagation of *Polypodium proliferum* Roxb.

G. P. MAZUMDAR, Calcutta.

With a view to write a monograph on the Ferns of Bengal Plains the author is making collection of Ferns from different parts of Bengal. This is a preliminary report on one such collection. Some 30 years back David Frain published a catalogue of ferns occurring in the districts of Hooghly and 24-Parganas. With regard to the Fern Flora the list does not appear to be exhaustive.

In this connection *Polypodium proliferum* is very interesting. The specimens in possession of the author show a leaf of about 8 ft. in length and still it was growing. From the axils of almost every leaflet a vegetative bud is given out which, in some cases, has developed into a new plant. The distinction between compound leaf and simple one seems to have been obviated in this case. The anatomical nature of the origin of axillary bud is being microtomically studied, the result whereof will be read at the Congress.

The following is the list of Ferns collected :—

- | | |
|------------------------------|-----------------------------|
| 1. <i>Adiantum</i> | <i>P. irioides</i> |
| <i>A. caudatum</i> | <i>P. quercifolium</i> |
| * <i>A. capillus-veneris</i> | 7. <i>Hemionitis</i> |
| <i>A. lunulatum</i> | <i>H. cordata</i> |
| 2. <i>Pteris</i> | 8. <i>Acrostichum</i> |
| <i>P. longifolia</i> | <i>A. aureum</i> |
| * <i>P. crenata</i> | <i>A. scandens</i> |
| * <i>P. cretica</i> | 9. <i>Lygodium</i> |
| <i>P. pellucida</i> | <i>L. japonicum</i> |
| 3. <i>Ceratopteris</i> | <i>L. pinnatifidum</i> |
| <i>C. thalictroides</i> | 10. <i>Ophioglossum</i> |
| 4. <i>Asplenium</i> | * <i>O. vulgatum</i> |
| * <i>A. esculentum</i> | 11. <i>Helminthostachys</i> |
| * <i>A. longissimum</i> | <i>H. zeylanica</i> |
| 5. <i>Nephrodium</i> | 12. <i>Salvinia</i> |
| * <i>N. cicutarium</i> | <i>S. cucullata</i> |
| * <i>N. ciliatum</i> | * <i>S. natans</i> |
| <i>N. molle</i> | 13. <i>Azolla</i> |
| <i>N. unitum</i> | <i>A. pinnata</i> |
| 6. <i>Polypodium</i> | 14. <i>Marsilia</i> |
| <i>P. adnascens</i> | <i>M. minuta</i> |
| * <i>P. membranatum</i> | <i>M. quadrifolia</i> |
| <i>P. proliferum</i> | |

Species marked with an asterisk are not mentioned by Prain.

27. Origin of leafy sporophyte in pteridophytes : a discussion.

G. P. MAJUMDAR, Calcutta.

In this paper it is suggested that the leafy sporophyte (sporophore) originated in the same way from the thalloid gametophyte (e.g. Fern Prothallus) as the leafy moss plant (gametophore) originated from the Moss thallus (gametophyte); and the two generations in the Vascular Cryptogams are homologous.

28. Dichotomous branching in the leaves of *Pleopeltis simplex* Sw.

S. R. KASHYAP and P. N. MEHRA, Lahore.

The normal frond in *Pleopeltis simplex* Sw. is simple, lanceolate, entire. In some specimens of the species collected by Prof. Kashyap in the Jumna Valley in Tehri Garhwal, fully developed fertile leaves bifurcating once or twice have been found along with the usual simple ones on the same plant. Such fronds are of special interest in throwing some light on the systematic position of the genus. Their bearing on the relationship between *Pleopeltis* and the *Dipteridaceae* is discussed in

GYMNOSPERMS.

29. Some more peculiarities in the male cone of *Cycas circinalis* collected at Lahore in 1932.

S. R. KASHYAP, Lahore.

Several abnormalities have already been described by the writer in the male cone of this species, e.g. the large number of scales at the base below the stalk which often become fertile, the branching of the microsporophylls, etc. This year two cones show at the apex a cluster of typical long pointed scales such as are met with at the apex of the stem in the male and female plants. This brings the male cone still more closely in line with the female cones. Some more details are also discussed in the paper.

ANGIOSPERMS.

30. A short note on the arrangement of vascular bundles in the aerial parts of *Dracaena spicata* Roxb.

D. N. CHAKRAVERTI, Calcutta.

Concentric vascular bundles with phloem in the centre are found in the older aerial part of the shoot of *Dracaena spicata* Roxb. Sections from apical region show collateral vascular bundles. Transitional forms from collateral to concentric type can be traced in the subapical region of the shoot. The leaves with the stalk and the inflorescence-axis present only collateral vascular bundles.

Perhaps the concentric nature of the vascular bundles in the older part of the shoot may be due to the closely approximated nodes and the consequent overcrowding of a large number of leaf-trace vascular bundles within a comparatively smaller area. Possibly owing to the absence of leaf-trace bundles in the apical region of the shoot and in the inflorescence-axis the vascular bundles are all collateral.

31. On the taxonomy, distribution, ecology, and economic importance of the flora of the Hyderabad State (The Deccan Plateau). Part I.—The Dicotyledonous Angiosperms.

M. SAYEEDUD DIN, Hyderabad-Deccan.

The author has selected only a few plants from his work on the flora of Hyderabad, whose ecological, economic, and medicinal importance he wishes to discuss at some length. Although his original intention was not to describe the medicinal plants only, but to his great surprise he finds that the major part of his material is of immense medicinal value. Thus his work has become a small pharmacopœia of the Hyderabad plants. In his opinion Hyderabad affords an ideal field, so rich in variety of vegetation that it is worth while establishing experimental drug farms in suitable centres like Pakhal, Adilabad, and places like these which possess luxuriant plant growth. In his present work dealing with the above subject, the author has described about 75 families, 175 genera, and 300 species.

The plants described in this paper are the following:—*Strychnos Nux Vomica* (Loganiaceæ); *Grewia asiatica* (Tiliaceæ); *Cassia auriculata* (Leguminosæ—Cæsalpinieæ); *Andrographis paniculata* (Acanthaceæ); *Pongamia glabra* (Leguminosæ—Papilionaceæ); *Opuntia Dillenii* (Cactaceæ); *Solanum nigrum* (Solanaceæ); *Adansonia digitata* (Malvaceæ); *Lantana camara* (Verbenaceæ); *Butea frondosa* (Leguminosæ—Papilionaceæ); *Abrus precatorius* (Leguminosæ—Papilionaceæ); *Mucuna pruriens* (Leguminosæ—Papilionaceæ).

He has laid special stress on their ecological, economic, and medicinal importance. In his opinion Hyderabad can very well become one of the most important centres for supplying the drugs to the whole of India. The importance of the study of drug-flora and the establishment of experimental stations cannot be over-estimated. It is high time that such work should be encouraged, and more importance be laid on this branch of study than has so far been done. He is extremely glad that work of this nature has also been started in Northern India by Dr. S. K. Mukherjee of the Lucknow University.

32. A new species of *Dicraea*.

S. P. AGHARKAR and H. K. NANDY, Calcutta.

Material on which this species is based was collected by Prof. Agharkar from Cherrapunji, Khasi Hills, Assam. It occurs at an elevation of about 4,000 ft. on rocks in rapidly running mountainous streams towards Maosmai and Maomloo. A detailed study of the plant shows it to be a new species. Some of its characteristic features in respect of which it differs from *Dicraea Wallichii* Tul. with which it is allied are as follows:—

(i) The creeping thallus-like root which grows plagiotropically is closely attached to the rock, 2-3 cm. long and 4-7 mm. wide, the branches coalescing and giving rise to a flat irregularly disc-like structure on which the secondary shoots bearing flowers are borne.

(ii) Secondary shoots are 1-2 mm. apart and crowded. In the vegetative condition the secondary shoot consists of 8-10 linear leaves, 6-8 mm. long. The tips of the bracts are 2-3 mm. in length.

(iii) Spathella funnel-shaped from 5-10 mm. long becoming toothed at the apex after the pedicel of the flower has burst through it.

(iv) Pedicel of flower about 4-8 mm. long, elongating in fruit to 8-10 mm.

(v) Stamens equalling or exceeding in length the ovary with the stigmas.

(vi) Capsule 1½-2 mm. long, ellipsoidal, 10 or 11-12 ribbed.

The species appears to be of rather rare occurrence as it has been collected only once in spite of repeated search in the same locality by both the authors.

33. Some additions to our knowledge of *Dicraea Wallichii* Tul.

S. P. AGHARKAR and H. K. NANDY, Calcutta.

As a result of a detailed study based on large numbers of living and preserved specimens, the authors find that Willis' account of the species has to be modified in the following particulars:—

(1) The Spathella is 6-10 mm. long and not up to 6 mm. long as mentioned by Willis.

(2) The authors have not been able to confirm Willis' statement that the var. *Khasiana*, which alone is found at Cherrapunji, has 8-ribbed capsules.

As all the specimens examined by the authors have only 10 ribs, the distinction between varieties *Khasiana* and *striata* of Willis appears to break down.

34. Abnormality in *Cucurbita Pepo*.

P. K. BOSE, Calcutta.

~~Abnormal~~ flowers and fruits of *Cucurbita Pepo* were observed which also bore a number of normal flowers

The abnormalities in the flowers and fruits collected have been observed as follows :—

1. Flowers *hermaphrodite*.
2. Ovary *distinctly half-inferior*; corolla persistent surrounding the fruit; the stamens have been inserted on the corolla forming a ring around the ovary.
3. Fruits apocarpous; all the three carpels are free, each forming a separate fruit, enclosed within the common receptacle.

35. Studies in pollination of flowers by moths.—I.

T. C. N. SINGH, Cuttack.

Flowers of *Quisqualis indica* L., *Holarrhena antidysenterica* Wall., *Jasminum mauritianum* Bojer, and *Vinca alba*, growing in the Botanical Garden of Ravenshaw College, Cuttack, are regularly visited by Sphingid Moths at night but only under the cover of the soothing influence of moon-shine. Search for them with electric-torch during the dark hours of night, has so far proved futile, but not unoften they may be seen darting about from flower to flower at dusk and I have also incidentally seen them busily hovering about the flower-bunches of *Q. indica* L. growing near an electric-lamp.

36. Viviparous germination of seeds in balsam (*Impatiens balsamina*).

G. P. MAJUMDAR, Calcutta.

Out of about one hundred plants growing in the author's garden only one plant with pink single flowers shows this phenomenon in all its fruits. Seedling is a normal plant with a comparatively long hypocotyl and a pair of well developed green cotyledons. The growth of the radicle, at first normal with root-hairs, is soon arrested, and from the base of the hypocotyl a fairly large number of thin roots spread in all directions along the inner surface of the fruit-wall forming an entangled mass. On bursting of the fruit all seeds—germinated and ungerminated—mingled together fall to the ground; and some of the viviparous seedlings thus set free are growing around the mother plant.

37. Abnormalities in the inflorescence of *Calendula* sp.

K. L. SAKSENA, Gwalior.

One specimen exhibits a case of proliferation where the mother axis after producing a capitulum, continues its growth from the middle and ends in another smaller capitulum at the top. It also shows two smaller capitula arising from the axils of bracts situated at the margin.

Two other specimens show nine or twelve smaller capitula respectively arising from the margin of the large central capitulum and forming umbels of heads.

38. Explosive fruits in *Viscum japonicum* Thunb.

B. SAHNI, Lucknow.

It is generally believed that the seeds of the genus *Viscum* are dispersed by birds, who eat the viscid pulp and leave the seeds sticking to the branches of trees on which they rub their beaks. This is certainly true of *V. album* but not of *V. japonicum*, which grows abundantly on *Quercus incana* in some parts of the Western Himalayas. I have recently had under observation a minute obovoid fruit (scarcely 2 mm. l.)

retains its green colour. It ripens during the rainy season, and then becomes somewhat translucent, so that the seed is just visible through the pericarp in the broader distal part of the ovary. Dispersal takes place by a violent ejection of the seed from the top end of the ovary which bursts as the result of increased turgidity. Twigs of *V. japonicum* bearing ripe fruits, if disturbed by shaking in the wind, throw off the seeds to a distance of over two feet. Ripe fruits attached to twigs, left immersed in a basin of water, were found to have ejected their seeds to a distance of several inches under water.

39. Chromosome number and development of embryosac in
Trichosanthes dioica Roxb.

M. C. DAS, Calcutta.

The somatic chromosome number of the male and female plants of *Trichosanthes dioica* was found to be 22 in each case. Investigation on the cytology of the plant which is in progress also shows 11 bivalent chromosomes.

The development of the embryosac is of the normal type. A group of archesporial cells differentiate in the third layer of the nucellus, of these one functions as the megaspore mother cell. As a result of two divisions the megaspore mother cell produces a tetrad of megaspores. The innermost (chalazal) megaspore functions, while the other three degenerate. An eight nucleate embryosac is produced, in which the egg apparatus, the polar nuclei, and the antipodals are arranged in the usual way.

40. The pollen development in *Cassia tora* Linn.

R. M. DATTA, Calcutta.

The nuclei of the archesporial cells in the anther loculus contain more than one nucleolus. Deep staining chromatin granules have been noted in the cytoplasm of the cells in the resting stage. Nucleolus in the resting stage contains vacuoles in which more than one crystalline bodies have been noted. The peripheral 'net-knots' in the nuclear hyaloplasm are evident in the prophase stages. No crystal bodies however are seen in the late prophase. A nuclear protuberance is noted at this stage. During synizesis the nucleolus is not enclosed in the reticulum but lies eccentrically. Connection of the leptotene thread with the nuclear protuberance was not observed. The pachytene thread is beaded in appearance. It breaks into segments. These segments show the parallel association of two chromosomes and suggest parasynaptic pairing. There is no second contraction stage. In diakinesis the chromatin substances of the chromosomes condense and form bivalents leaving behind the 'thread mass' in the nuclear cavity. The thread mass is reticulate in structure and does not take stain. The bivalents become peripheral. The origin of the spindle-fibres is intra-nuclear and the multipolar spindle ultimately becomes bipolar in form. 'Laggards' have been noted in the heterotypic and the homotypic anaphases. During telophase fresh nucleoli appear in the daughter cells. More than one nucleolus has been sometimes noted in the daughter nuclei which later on fuse to form a single one. Cytokinesis takes place by furrows. Tetrads are enclosed by a mucilaginous pellicle. Pollen grains are uni-nucleate at first but when fully developed become bi-nucleate. The haploid number of thirteen (13) chromosomes has been counted in this plant. The tapetal cells are uni-nucleate at first but mitoses take place and they become tri- and tetra-nucleate gradually, as there is no formation of any cell wall after each mitosis. No stout processes of the nucleoli have been observed.

41. Anatomy of the stamens and the ovules of certain abnormal flowers of *Argemone mexicana* Linn.

A. C. JOSHI, Benares.

The paper describes the structure of the stamens and ovules of certain abnormal flowers of *Argemone mexicana*, the external morphology of which was described by the writer last year. The filaments and the connectives of these stamens have been found to possess stomata on both the sides. The anthers are devoid of the endothecial layer with characteristic bands and consequently never open. In the ovule, the integuments always remain free from each other and the nucellus. The inner integument possesses stomata on both the surfaces, while the outer only on the inside. The vascular bundle of the ovule in the region of the chalaza sends out branches into the inner integument and the nucellus. Embryosac degenerates and no embryo is formed. The significance of these variations from the normal is discussed.

42. Secondary thickening in the stem of *Stellera chamaejasme* L.

A. C. JOSHI, Benares.

The anatomy of the roots of *Stellera chamaejasme* L. was described by the writer at the last session of the Science Congress held at Bangalore. It has now been found from dry herbarium material of the species that its stem grows in thickness by a succession of supernumerary cambial rings arising one after another and each forming a zone of wood and bast.

43. Further observations on the internal bundles of *Rumex orientalis* Bern.

A. C. JOSHI, Benares.

Internal bundles consisting of phloem only and increasing in girth by a concentric zone of cambium have been seen in the hypocotyl of *Rumex orientalis*. They lie quite free in the pith and are not attached to the bundles of the outer ring. The significance of these observations is discussed and it is concluded that these support the origin of peculiar internal bundles of *Rumex*, from ordinary medullary bundles.

44. An abnormal androecium of *Poinciana regia* Boj.

A. C. JOSHI, Benares.

A flower of *Poinciana regia* was collected with a pinnate stamen, bearing three anthers.

45. Medullary bundles of *Achyranthes bidentata* Blume.

A. C. JOSHI, Benares.

Achyranthes bidentata also possesses two medullary bundles in the internodes of the stem like *A. aspera*. Their course is also similar. There is, however, one difference in structure. The medullary bundles of *A. bidentata* in every part of the shoot exhibit an anomalous type of secondary thickening by an accessory cambium formed on the outside of the phloem. This condition was only once seen in the medullary bundles of the inflorescence axis in *A. aspera*.

46. Variations in the structure of the medullary bundles of *Achyranthes aspera* and the original home of the species.

A. C. JOSHI, Benares.

Material of *Achyranthes aspera* from different parts of the country, namely, Bombay, Calcutta, and Benares, in addition to that from Lahore, has been studied. It has been found that the free condition of the two medullary bundles, which are characteristic of the species, is dominant in the internodes of Calcutta and Bombay plants, while the fused condition prevails in the Lahore plants. Benares plants show an intermediate condition. From these variations it is concluded that the original home of the species was in the tropics and from there it has gradually spread out to the subtropical and temperate parts.

47. Megaspore-formation and embryosac of *Argemone mexicana* Linn.

A. C. JOSHI, Benares.

The megaspores of *Argemone mexicana* form a T-shaped tetrad. The embryosac is characterised by very large antipodals. A good deal of endosperm is formed before the fertilised egg begins to divide.

48. Comparative anatomy of the flowers of *Ficoideæ* and *Nyctaginaceæ*.

V. SITARAMA RAO, Benares.

The paper describes the anatomy of the flowers of *Mollugo hirta*, *M. verticillata*, *M. stricta*, *Geisekia pharnaceoides*, *Trianthema monogyna*, *T. pentandra*, *Bougainvillea spectabilis*, *Boerhaavia diffusa*, *B. repanda* and *Mirabilis jalapa*. A comparison is made between the anatomy of these flowers and those of other plants whose floral anatomy is known and the bearing of these results on the theory of carpel polymorphism is discussed.

49. Sun-birds in relation to certain angiospermous flowers.

T. C. N. SINGH, Cuttack.

A species of sun-bird (both male and female) visits *Russelia juncea* (Scrophulariaceæ), *Quamoclit pinnata* (Convolvulaceæ) and *Tecoma stans* (Bignoniaceæ) in the Ravenshaw College Botanical Garden, during the comparatively cool hours of the day. Continued observations have demonstrated that in *Russelia juncea* and *Quamoclit pinnata* these birds act as pollinators while in *Tecoma stans*, they steal the honey by making punctures near the base of the corolla-tube, without apparently doing any service to the plant.

50. Micro- and mega-sporogenesis in *Cassia purpurea* Roxb.

S. L. GHOSH and R. ALAGH, Lahore.

I. *Microsporogenesis* :—

In the archesporial and spore-mother cells the nucleoli are spherical and of a fairly large size. The tapetal cells are usually bi- and tri-nucleate, but as many as six or seven nuclei have been seen in certain cases. In the synzesis stage the thread forms a tight knot and cannot be followed. There are chromatin granules scattered on it. The spireme in heterotypic prophase is connected by one of its ends to the nucleolus. The nucleolus remains spherical throughout the prophase. The number

of haploid chromosomes is ten and the chromosomes represent a case of telosynapsis. The spindle is tripolar at first, but later on becomes bipolar. It is intranuclear in origin. No nucleolus was seen at metaphase. No anaphase was seen either in the heterotypic or in the homotypic division of the nucleus. At telophase ten chromosomes were seen in one of the daughter-nuclei. Two big lumps of chromatin were seen, which fuse to form a single nucleolus. Transitory plate formation was observed at telophase. No spireme stage was observed at homotypic prophase. The tetrad formation is by furrows. Perinuclear zone of cytoplasm is seen round the spindle during metaphase and telophase. The nucleolus does not exclusively supply stainable material to the reticulum.

II. *Megasporogenesis* :—

Only a single hypodermal archesporial cell is present. The megaspore mother-cell is deeply embedded in the nucellus. Only a single linear row of four megaspores is seen. The most remarkable thing is that the second megaspore is functional in this plant. The division of the functional megaspore takes place very quickly. The antipodals are very conspicuous. It appears that the triple fusion takes place after fertilisation.

51. A contribution to the cytology of *Ranunculus muricatus* Linn.

S. L. GHOSE and KOSHENDRA NATH, Lahore.

I. *Microsporogenesis* :—

The primary sporogenous cells possess binucleolate nuclei. The synizetic knot is peculiar for the absence of any visible reticulum and for its very even structure. The open spireme stage consists of ribbon-like tangled mass. In the metaphase, the chromosomes do not remain perfectly separate from each other, but group themselves into a few flat irregular plate-like structures. There is no interkinesis stage between the first and second mitotic divisions.

II. *Megasporogenesis* :—

There is no parietal cell present. There is invariably only one archesporial and one embryosac mother cell. The antipodals differentiate early, are larger than all parts of the embryosac, and persist for a very long time.

III. *Endosperm and Embryo* :—

The endosperm begins to develop even before the fusion of the gametes. The embryo appears to be formed at a very late stage.

52. Some stages in the microsporogenesis of *Luffa acutangula* Roxb.

S. L. GHOSE and KOSHENDRA NATH, Lahore.

I. *Presynizesis* :—

The nucleolus is large and spherical and placed a little away from the centre. The reticulum is at first fine and meagre. Leptotene threads concentrate towards one side in connection with the nucleolus. It was not possible to see whether they paired parasynaptically or not.

II. *Synizesis* :—

The synizetic knot is formed in one corner of the nuclear cavity, and consists of a rather compact mass of convoluted leptotene threads. The threads are not double but single and uniform. The nucleolus may

be variously placed but usually it is enveloped within the synizetic knot. Many cells at this stage show some small scattered granules attached to the inner side of the nuclear membrane. The leptotene threads are at first thrown out in the form of loops before spreading out into the nuclear cavity.

III. Open-spireme stage:—

The first formed spireme loops ramify in the nuclear cavity, which has contracted a little. The threads are uniform in character, show no double nature and are continuous with each other. The nucleolus is small but always present. The network spreads out fully.

53. The wood anatomy of a homoxylous dicotyledon, *Tetracentron sinense*.

B. SAHNI, Lucknow.

The rare monotypic genus *Tetracentron* is one of those interesting primitive dicotyledons, allied to the Magnoliaceæ, which are distinguished by an absence of true vessels in the wood, and which Van Tieghem segregated under the special group Homoxyleæ. The peculiar wood structure of *Drimys*, *Trochodendron* and *Zygogynum* is already well-known, but that of *Tetracentron* has only been briefly described. The present detailed investigation was made possible through the kindness of Prof. Harms who generously sent to the author a small twig 3 to 4 years old from a herbarium specimen collected by Henry in the Hupeh province of China.

The description given by Harms, Thomson, and Bailey is on the whole confirmed, but there is no appreciable difference from *Trochodendron* in the size of the tracheids. In its wood-anatomy the genus stands definitely nearer to *Trochodendron* than to the other homoxylous forms, the chief points of resemblance being the preponderance of scalariform pitting (with occasional transitions to the multiseriate type) in the spring wood, and the relatively strong development of autumn wood.

Among the modern angiosperms, these two monotypic genera from the Far East offer the nearest affinities yet discovered with the fossil angiospermous wood from the Rajmahal Hills recently described by the author under the name *Homoxylon rajmahalense* (*Proc. 18th Ind. Sci. Congr., Nagpur, 1931, p. 279*; full description in *Mem. Geol. Surv. Ind., Palæont. Ind., N.S., Vol. XX, Mem. No. 2, pp. 1-19, pls. I-II, 1932*).

54. The relation between the evolution of carbon dioxide and the loss of carbohydrates in the aerobic and the anaerobic respiration of the germinating seeds of rice.

R. H. DASTUR and R. M. DESAI, Bombay.

The evolution of carbon dioxide by the germinating seeds in air and in nitrogen is measured under constant and uniform conditions for nine days. The analysis of the carbohydrate contents of the seedlings before and after the respiration is measured is made every day. The results show that both in aerobic and anaerobic respiration the actual output of carbon dioxide is in excess of the carbon dioxide calculated from the total loss of carbohydrates taken as hexoses. Many other interesting facts are also brought to light by this investigation.

55. A new microchemical method of detecting minute traces of reducing sugars in the plant cells.

K. S. PIMPALKHARE and R. H. DASTUR, Bombay.

A method is devised by which the reducing sugars can be readily detected in plant cells. By this method one part of hexoses in 80,000 parts of water is easily estimated.

56. The formation of carbohydrates in leaves in elliptically polarised light.

R. H. DASTUR and L. K. GUNJIKAR, Bombay.

An apparatus is devised so as to obtain a very large beam of elliptically polarised light sufficient to illuminate two potted plants. The ellipticity of elliptically polarised light is determined by the Babinet's compensator. There is no indication of an increase in the formation of carbohydrates in leaves in elliptically polarised light as compared to the formation of carbohydrates in leaves exposed to normal light of the same total intensity.

57. Geotropic curvature in certain angiospermous flowers.

P. PARLJA and T. C. N. SINGH, Cuttack.

Epiphyllum.—Observations made both in the dark and in light, have shown that the perianth-tube of the long pendulous flower of *E. Hookeri* becomes curved like a hook just a few days before it actually unfolds. Later, due to the weight of its own developing perianth-lobes, the curved portion dangles down with a corkscrew-like torsion on the perianth-tube, as one would naturally expect in such a case. The flower, however, if kept vertically erect, before it actually curves up, never manifests the characteristic hook-like bend and the growth of the perianth-tube is straight. Flowers kept in horizontal position, nevertheless, also do curve upwards but just a little.

Hibiscus.—In *H. Rosa-sinensis* and *H. schizopetalous* also, the flowers in natural condition are pendulous and the petals are deflexed backwards such that the calyx remains hidden from view. However, when the flowers are supported in a vertically erect position like *E. Hookeri*, the petals bend centripetally (at least by 45°) towards the staminal column.

It is concluded that these bendings of the perianth-tube in *Epiphyllum* and of the petals in *Hibiscus* are a result of geotropic response. Study to locate the perceptive region in each case is in progress.

58. Clothing hairs on the roots of some plants.

D. N. CHAKRAVERTTI, Calcutta.

The roots of following plants have been observed to be covered for several inches behind the root-cap by very closely-set persistent hairs, which are unicellular, either white, long and bent, or brownish to deep brown in colour, short and more or less straight.

Dicotyledonous plants:—*Ficus bengalensis*, *Ficus religiosa*, *Ficus infectoria*, *Mangifera indica*.

Monocotyledonous plants:—**Gramineæ**, Rice (*Oryza sativa*), Wheat (*Triticum vulgare*), Maize (*Zea mays*), Sugarcane (*Saccharum officinarum*), Bamboo (*Bambusa arundinacea*), many grasses, **Scitamineæ**, Ginger (*Zingiber officinale*), *Canna indica*, *Musa sapientum*, **Commelinaceæ**, *Tradescantia zebrina*, *Tradescantia discolor*, and **Liliaceæ**, *Dracæna spicata*. These hairs grow so abundantly as to clothe the roots like a whitish or brownish felt, hence they might be called 'Clothing Hairs' as distinct from the absorptive root-hairs limited only to the area just behind the apex. These clothing hairs are devoid of living cell-contents as they remain unstained with dilute neutral red solution and their cell-walls respond to the cellulose test.

Probable functions of the clothing hairs are that—

- (a) they form a protective felt round the root,
- (b) they are hygroscopic, acting as velamen,
- (c) they hold the root firmly to the substratum.

PHYSIOLOGY AND ECOLOGY.

59. Observations on the stomatal distribution and the rate of transpiration in wilting leaves.

T. S. RAGHAVAN, Annamalainagar.

Stomata have been counted and observations made in regard to their distribution in different plants and in the different parts of upper and lower leaves of each of plants. The Halophytes are characterised both by a general higher stomatal frequency and by a higher rate of transpiration than the mesophytes and cannot therefore be termed xerophilous. The rate of water loss is not directly proportional to the number of stomata per unit area. The rates are found to vary inversely as a certain increasing function of S (stomatal frequency) and I (stomatal index). It is suggested that in wilting leaves as in ordinary transpiring leaves the loss of water is not a physical process controlled by the stomata but is attributed to the water content of the leaves, and is a result of the adjustment of the internal conditions. This is also supported by the presence of fluctuations in the rates of transpiration in the initial stages of the wilting of the leaves. The closure of stomata which are held to be the primary cause of the decline in transpiration in wilting leaves is only subsequent to the water deficit, a slight increase of which does not affect the transpiring power of the wilting leaves and therefore these show all the characteristics of normal transpiring leaves till the maximum water deficit which varies with different plants, is reached. The closure of stomata which is only secondary and which takes place subsequently only tends to decrease the rate of water loss further.

60. Studies in the respiration of *Psidium Guajava*, in relation to its sugar and acid contents, while passing through a senescent drift.

S. RANJAN and Z. A. KHAN, Allahabad.

It was found that with the increase of age the sugars and acids increase.

The increase in sugar was about 25 times while that of acids was only twice.

Up to about the age of a month the respiration increases and then it begins to fall showing a senescent rise at the end of the life of the fruit on the tree.

A correlation has been observed between the colour, surface condition, sugars, acidity and respiration. In dark-green guavas the sugars and acids were small but the respiration was high, in yellow green the reverse was the case while in golden yellow all the three were high.

A starving guava of a mature age behaved exactly like the cherry-laurel leaf or an apple; whilst a young one showed no senescence, a ripe one did not exhibit the floating and the protoplasmic phases of respiration.

Acids and sugars decreased in storage but both showed a rise when senescence occurred. The rise was followed by a quick fall.

The pitch of the maximum rise in the sugars depended upon the length of time the guavas remained in the chamber before senescence occurred. It being high in cases when it occurred after a day or two and low when senescence occurred after 5 or 6 days in the chamber.

The pitch of the maximum rise in acids was indifferent to the length of time the guavas remained in the respiration chamber.

Finally an attempt has been made to show a direct correlation between sugars and acids, and acids and respiration.

61. A study of the influence of soil moisture and manure on transpiration and water requirements of peas and grams.

D. R. MEHRA, Lahore.

The rate of transpiration calculated per plant per day shows a progressive increase with the advance of the season till the maximum is reached, after which there occurs a slight fall. The yield of the plants increases with the increased soil-moisture and increased soil-fertility. With an increase in the moisture content of the soil, there is an increase in the water-requirement. This is true up to a certain limit, after which the water requirement ratio decreases with the increase in the soil moisture. The fertility of soil decreases the water requirement ratio. The water requirement for peas is comparatively lower than that of grams under the same environmental conditions, as obtained in the Green House.

62. A study of the influence of temperature on the growth of root-hairs of tomato and cabbage in various concentrations of calcium chloride solution.

D. R. MEHRA, Lahore.

The results of the experiments show that (1) the root-hairs show a definite response to the influence of temperature and that for a certain set of conditions their growth in calcium chloride solution increases with an increase in the temperature of the solution. This increase goes on till the limit of the optimum temperature, after which the growth falls down with an increase in the temperature of the solution. (2) The same rule applies to that of the concentration of the calcium chloride solution. With increased concentration of the solution, the root-hairs show a greater growth. This too is limited till the optimum concentration is reached after which the growth decreases with the increased concentration. (3) That for a certain set of conditions, the longer root-hairs show a greater amount of growth as compared to smaller ones, and that the exceptionally long root-hairs show no growth at all. This is most probably due to the fact that these root-hairs had grown to their maximum length before our observations were started. (4) The root-hairs show a definite periodicity in the rate of elongation. If the observations are prolonged, the rate of elongation of the root-hairs does not remain constant throughout.

63. Injection of salts in the control of chlorosis in citrus plants.

H. CHAUDHURI, Lahore.

This paper deals with a chlorosis found commonly in the Lahore orchards. The leaves show mottled appearance and drop down early. The mottled leaves seem more brittle. In very bad infections all the leaves show chlorosis. Preliminary experiments were done with cut twigs which were placed in the following salt solutions:—Ferric phosphate, Ferrous phosphate, Ferrous sulphate, Ferric sulphate, and Iron alum of .01, .001 and .0001% solution. Control twigs were placed in sterilised tap water. Those solutions only which gave favourable results were next tried for spraying and injecting the plants. The paper deals with the details of the experiments done. Injection with Ferrous sulphate (1 in 10,000) and also spraying, gave very good results and recovery from chlorotic condition was noticed. Ferrous phosphate in the same strength also gave good result.

64. Studies in the physiology of parasitism. Effect of one organism on the parasitic activity of the others.

R. SAHAI VASUDEVA, Lyallpur.

In this paper the effect of one organism on the activity of the other is dealt with and a detailed account of the reduction of parasitic activity in mixed inocula of a large number of fungi is given.

A physiological analysis has been attempted in the case of certain fungi, both parasitic and non-parasitic, using a variety of hosts.

65. On the physiology of parasitism: An analysis of the factors underlying specialisation of parasitism with special reference to certain fungi parasitic on apple and potato.

B. CHONA, Lahore.

It is well known that fungi vary widely as regards the range of host plants which they are able to attack. Certain fungi, which are parasitic on apple are unable to attack potato. Similarly another set of fungi, which are parasitic on potato do not under normal conditions attack apple tissue. Such failure of the fungi, normally parasitising one host, to attack another has been explained on the basis of the activity of their Pectinase enzymes in relation to the plant extracts of various hosts.

66. On the distribution of freshwater plants in India.

S. K. MUKERJI, Lucknow.

It was generally believed that freshwater being an uniform habitat, the floristic composition of the aquatic vegetation of various inland lakes, wheels and rivers in India would show a great similarity. But having worked for the last 15 years on the correlation between the freshwater flora and the 'Climatic Complex' of the region, especially in respect of the temperature, humidity, and pH relations, the author considers that from this point of view, the freshwater plants may be grouped into three main categories:—

Tropical Forms—e.g. *Jussieua repens*, *Trapa bispinosa*, *Neptunia oleracea*, *Lagarosiphon Roxburghii*, *Blyxa Roxburghii*, *Ottelia alismoides*, *Wolffia* sp. *Eichornia speciosa*.

Temperate Forms—e.g. *Alisma Plantago*, *Triglochin palustre*, *Trapa natans*, *Salvinia* sp., *Hippuris vulgaris*, *Callitriche verna*, *Myriophyllum verticillatum*, *Hydrocharis morus-ranae*, and *Sparganium ramosum*.

Cosmopolitan Forms—e.g. *Hydrilla verticillata*, *Vallisneria spiralis*, *Monochoria vaginalis*, *Zannichellia palustre*, *Sagittaria sagittifolia*, *Butomus umbellatus*, *Lemna* sp., *Najas minor*, *Nelumbium speciosum*, *Utricularia flexuosa*, and *Marsilea* sp.

67. Invasion of *Eichhornia speciosa* in the interior of the United Provinces.

S. K. MUKERJI, Lucknow.

The intrusion of the water hyacinth (*Eichhornia speciosa*) into the United Provinces is proceeding so rapidly as to constitute a future menace which, if unchecked, may assume proportions comparable to those of Bengal. Districts completely immune from this pest, as recently as 20 years ago, are now replete with it. The invasion has not been confined to the more easterly districts such as Benares and Mirzapur, but has progressed to northern districts such as Basti and Gorakhpur and even to the extreme west as in Dehra Dun and Hardwar.

It has been observed that propagation mainly takes place in two ways. The attractive flowers of this plant are plucked by villagers and conveyed from place to place. Birds also carry portions of plants from locality to locality.

68. Some observations on the anomalous distribution and ecology of *Nymphæa tetragona* Georgi.

S. K. MUKERJI, Lucknow.

Out of all the water-lilies found in India, *Nymphæa tetragona* Georgi (syn. *Nymphæa pygmæa* Aiton) is one of the most interesting types from the point of view of its peculiar geographical distribution and its ecological relations. The author has studied this plant for a number of years both from his collections made at Gulmarg in Kashmir and from herbarium material at Kew and Royal Botanic Gardens, Sibpur.

As far as its distribution in India is concerned, *N. tetragona* has been recorded so far from only two localities—(1) Gulmarg in Kashmir, and (2) Nongkreem on the Khasia Hills. No one has collected this plant from any other locality in India. It is suggested that accidental transport by migratory birds has probably been the cause of this anomalous distribution.

This paper also embodies observations relating to the phenology and ecological relations of *N. tetragona*.

69. The rôle of *Parrotia jacquemontiana* Dene. in the forest ecology of Kashmir State.

S. K. MUKERJI, Lucknow.

Parrotia jacquemontiana Dene. occurs as an underwood in various kinds of woodlands in Kashmir. It produces rank growth in Deodar, blue pine and silver forest at altitudes between 3,000 ft.—8,500 ft.

Since it impedes the reproduction of such valuable trees as *Cedrus Deodara*, *Pinus excelsa* and others, drastic methods, i.e. burning entire underwoods of *Parrotia* have been, more recently, resorted to, in order to eradicate the pest from certain localities in Kashmir.

The author's observations lead him to believe that wholesale burning of forest undergrowth produces profound changes in the physico-chemical properties and microbiological population of the soil, which instead of being beneficial are positively detrimental to the natural regeneration of both Deodar and blue pine. Apart from the fact that it is used as fodder for cattle, fuel for villagers and in making tool-handles, wicker work and rope bridges, its ecological importance in the general economy of Kashmir forests, especially in connection with afforestation schemes, must not be underrated. In fact the observations tend to show that *Parrotia* actually improves the soil and in nature is a definite ecological stage in succession which prepares the way for the migration and ecesis of the Deodar in those localities which are initially unfit for its (Deodar) growth.

MISCELLANEOUS.

70. A quick method of studying epidermal structure of leaf.

T. C. N. SINGH, Cuttack.

A substance looking like rubber-solution sold in collapsible tubes in the market under the name of 'Durofix' is thinly but evenly applied to the surface to be examined. So done, it is left untouched for about 5-7 minutes to dry. Afterwards the dry 'Durofix' is easily stripped off (in certain cases when left untouched for a sufficiently long time, the 'Durofix' scales off by itself) in big pieces by the help of a pair of blunt

forceps. The strips so obtained may be mounted dry or otherwise under a cover glass and examined. These strips give a very faithful print of even the minutest detail.

71. On the teratology of certain Indian plants—XVI.

T. C. N. SINGH, Cuttack.

The author describes certain abnormalities of flowers in

(a) *Cannabis sativa* Linn. (b) *Agave rigida* Mill. (c) *Datura Stramonium* Linn. (d) *Polianthes tuberosa* Linn. and of leaves in (a) *Eranthemum*? *bicolor*, and (b) *Lagerstrœmia indica*, Linn.

72. Medicinal plants of Dacca and Mymensingh.

H. K. DATTA, Dacca.

This paper has been written in response to the appeal made by Dr. S. K. Mukherjee for a survey of the medicinal plants of India, in a paper read before the Botanical section of the last Indian Science Congress held at Bangalore. A list of the medicinal plants of Dacca and Mymensingh is given. No mention is made of the medicinal properties of those plants that have been described in the 'Medicinal Plants of India' by Col. Kirtikar and Major B. D. Bose. Special mention is made of the plants that are used as antidotes to snake-poison. The vernacular names are given, as far as possible.

73. Studies in the eradication of the spike disease of sandal. Part I.—The use of arsenicals and other chemicals.

A. V. VARADARAJA IYENGAR, Bangalore.

The use of arsenicals in silviculture to kill undesirable shrubs and trees has lately been receiving increasing attention. The efficient removal of the source of infection in a spike affected locality cannot be minimised. It has been found that the effective killing of a spiked tree with a view to prevent further spread of the disease, is through the application of minimum dose of arsenic as sodium arsenite. The minimum is found to be high, reaching a value as much as 60 per cent. as As_2O_3 . Season influences slightly the effect of this agent.

Other tree-killers and poisonous agents have not been found to be very useful.

74. Studies on the spike disease of *Vinca rosea*.

A. V. VARADARAJA IYENGAR, Bangalore.

Vinca rosea Linn. known otherwise as periwinkle has been noticed to get spiked in the same way as sandal does. The typical features are a stunted growth, excessive branching and a diminution in the size of the leaves and internodes. The diseased parts of plants do not normally produce flowers, but in several cases, phyllody or green flowers have been noticed. The total effect of the disease results in stunting the growth of the plant. The plant with white flowers is generally affected.

A chemical investigation is undertaken to correlate this with sandal spike. Preliminary experiments show that in the diseased plants there is an increase in starch to the extent of $1\frac{1}{2}$ times than in the healthy and diminution in lime as compared with the healthy one. The ash content of the spiked leaf is 12% while that of the normal one is 9.65% on dry weight. The nitrogen content is higher in the diseased specimens, the respective values being 4% and 3.65% on dry weight.

75. Diseases of the tea bush.

K. L. BHATIA, Lahore.

Brown blight of tea due to *Colletotrichum camelliae* and grey blight of tea due to *Pestalozzia theae* have been studied in great detail. Isolations were made and physiology of the fungi studied. *Colletotrichum* produced the perfect stage in culture. Successful inoculations were made. Besides these, scab and spots due to *Phoma theicola*, *Hendersonia theicola* and red rust due to *Cephaleuros mycoidea* have also been studied.

76. A case of reversion of leafy form in Cocoanut inflorescence due to fungal infection.

H. CHAUDHURI, Lahore.

Inflorescences collected from Travancore showed that in many cases the female and the male flowers consisted only of clusters of leaves. In female flowers, the leaves were broad, whereas in the male, they were comparatively narrower. Sections of the inflorescences, showed in many cases, under the microscope presence of not only fungal hyphae but also oospores.

77. Study of the anatomy of the root-nodules of *Psoralea corylifolia* Linn.

P. ANAND and R. C. SAWHNEY, Lahore.

The present paper is a continuation of the one by the latter author on the 'Study of the Anatomy of root-nodules of a few Leguminous plants of Lahore', the abstract of which was published in the *Proceedings of the Indian Science Congress*, 1932.

The structure of the nodule of *Psoralea corylifolia* L. in general is similar to the nodules of plants already studied but with some very important characteristics. The central bacteroidal tissue comprising the bulk of the nodule consists of large, richly protoplasmic cells with comparatively big nuclei. The vacuoles appear at a later stage than in the root nodules of any of the Trifolae, the bacteria thus filling the cells almost completely in the form of short rods, curved or Y shaped forms. The bacteria in the infection threads are in the form of short straight rods.

Outer cortical tissue consists of parenchymatous sparsely protoplasmic and nucleated cells. In the outer region of the cortex a few layers of cells constantly contain white, transparent, long rod-shaped crystals, the chemical properties of which are being studied.

The vascular bundles for the nodule arise from the two proximal poles of the root and they divide and subdivide, the branches running in a slightly sinuous course in the cortex along the length of the nodule and end just behind the apex of the bacteroidal tissue. Curiously enough sometimes a branch of the vascular bundle runs in the opposite direction, i.e. towards the base of the nodule and ends blindly in the cortex of the nodule.

78. Study of the anatomy of the root-nodules of *Crotalaria tetragona* Roxb.

P. ANAND and R. C. SAWHNEY, Lahore.

The structure of the nodule of *Crotalaria tetragona* Roxb. is more or less similar to that of *Psoralea corylifolia*. Infection threads are, however, much less abundant and the vascular bundles do not give branches which

run towards the base of the nodule. No crystals of any kind were observed in the cortex. The structure in general resembles more that of the nodules of *Psoralea corylifolia* than that of any of those previously studied.

79. Embryo sac and the development of *haustorium* in *Sopubia* sp.

C. V. KRISHNA IYENGAR, Mysore.

The plant is found in the marshes as a parasite on the grasses. Some of the stages in the development of the root haustorium have been worked out. The ovules are arranged on a thick placenta filled with starch grains. The integument is very thick and the nucellar tissue is very much reduced. The small embryo sac is surrounded by tapetum of integumentary origin. The first two divisions of the fusion nucleus result in a row of three cells, the middle one developing into the tiers of endospermal cells of series of divisions. The other two cells give rise to the micropylar and chalazal haustoria by longitudinal divisions, the former four and the latter two in number. The micropylar haustoria drill a hole into the tissue of the integument in a conspicuous manner, at times this cavity reaching the outermost layer of the integument. This cavity occupied by the enlarging haustoria shows a coenocytic tendency during the later stages. There is nothing peculiar about the developing embryo.

80. Black rot of Coffee.

M. J. NARASIMHA, Bangalore.

A serious disease of Coffee, occurring in Mysore is caused by *Gorticium koleroga*. The interesting life history of this fungus is described. It was not hitherto clear in what way the fungus affected the Coffee leaf, as it has been considered to be an ectoparasite. The author's work throws light on this aspect of the question. A comparison is instituted between the Black rot of Coffee in Mysore, and similar diseases occurring in other parts of the world.

Section of Geology.

President :—PROF. N. P. GANDHI, M.A., B.Sc., A.R.S.M., D.I.C.,
F.G.S., M.INST.M.M.

Presidential Address.

I. THE PLACE OF GEOLOGY IN UNIVERSITY EDUCATION.

II. ORGANIZATION OF INDUSTRIAL MINERAL RESEARCH IN INDIA.

Introduction.—My first duty is to thank you for the honour you have done me in electing me to this chair. I am aware that this chair has been occupied in the past by many distinguished geologists who have not only advanced our knowledge of the geology of India but who have also made notable contributions to the science of geology. I am also aware that I can lay claim to no such distinction. The greater part of my life has been spent in the pursuit of mining and metallurgy—two branches of applied science which have much to do with geology—and I therefore think that your putting me in this chair must be due to your curiosity to know the uppermost geological thoughts of a mining and metallurgy man. I propose to address you to-day on the subject of the organization of industrial mineral research in India, but before I do so, I wish to enter a plea for a greater provision for the teaching of geology at the Universities in India, fully supporting the views put forward by Mr. Wadia on this subject in his Presidential Address to this Section of the Congress twelve years ago.

I. THE PLACE OF GEOLOGY IN UNIVERSITY EDUCATION.

Aims and objects of pure geology.—My survey of the various branches of science has led me to the conclusion that there is none which is more fascinating than geology. To unravel the mode of origin and history of our planet, hundreds if not thousands of millions of years old, to establish the sequence of genera and even species of the animals and plants that have peopled the earth right from the time life began on the planet, to offer a reasoned guess as to the probable composition, structure and condition of the interior of the earth—a globe of four thousand miles radius of which only about a mile is penetrable, to explain the present dispositions of continents and oceans, of altitudes and climates, of volcanoes and earth-

quakes, of animals and plants, of igneous, sedimentary and metamorphic rocks, and so on, and to trace the histories of their dispositions through hundreds of millions of years—are these not amongst the grandest occupations of the human mind? Show me a branch of science in which there is greater scope for powers of observation, greater field for the cultivation of imagination and greater thrill in the results obtained, than in geology.

Cultural value of geology.—As a cultural subject, too, geology stands pre-eminent. The cultural value of a scientific subject depends upon the ease with which, and the extent to which, its study develops the scientific mood and teaches the scientific method. The characteristics of the scientific mood are—a passion for the facts of nature, a cautiousness in making statements, a clearness of vision and a sense of the inter-relatedness of things. Scientific method consists in the collection of accurate data, the arrangement and classification of facts, the analysis or reduction to simpler terms, and the formulation and testing of hypotheses, with a view to discovering the laws of Nature.

In order to realize how well the above characteristics are exemplified in the rise and growth of the science of geology, one has only to read Hutton's great work 'Theory of the Earth with Proofs and Illustrations', Playfair's 'Illustrations of the Huttonian Theory' and Lyell's 'Principles of Geology'. He will there see with what marvellous enthusiasm and thoroughness the pioneers of the science collected the basic facts, how they withheld judgment when the data appeared incomplete, how they doubted conclusions hastily reached, how they hesitated to accept what appeared attractive on account of its simplicity or symmetry, and how their suspended judgment was a triumph of their intellectual discipline. This tradition has become the heritage of the subsequent workers in the field.

Geology is a fine example of a science built up almost entirely by inductive reasoning, and combines the methods and concepts of several of the fundamental sciences in attacking its problems. It is a synthetic science. It illustrates better than probably any other science the wide ramifications and inter-relations of physical phenomena. As Prof. Woodward says :—

'There is scarcely a process, a product or a principle in the whole range of physical science, from physics and chemistry up to astronomy and astrophysics, which is not fully illustrated, in its uniqueness and in its diversity, by actual operations still in progress on the earth, or by actual records preserved in her crust.'

The earth is thus at once the grandest of laboratories and the grandest of museums available to man.

And it is a very different kind of laboratory from that

of physics or chemistry or biology. In the former, we can only study the natural course of events; in the latter, we can arrange artificially for certain things to occur. The method of experiment saves time and we can make surer of the conditions. In studying the effect of electric discharges on living plants, it would be at least tedious to wait for the lightning to strike trees in our vicinity, and so we imitate the natural phenomena in the laboratory. In studying hybridization, we are on much surer ground with experiment than with observation in natural conditions.

The commonest laboratory method of finding the effect produced by a given factor is to arrange a series of experiments in which only that factor varies. But this easy method of altering the conditions of occurrence to suit our purpose is usually denied in studying the phenomena of geology in Nature. There we have to deal with multiple and often complex variables, which makes the task of collecting and classifying the data, formulating hypotheses and discovering laws much more difficult. A greater play of the imaginative faculty and a sounder sense of judgment are called for, and geology is well known for developing these qualities in its votaries to a marked degree.

There is in the human intellect a power of expansion which is brought into play by simple brooding over facts. Imaginative brooding suggests a solution in some way that we do not clearly understand. It may be that a sort of unconscious cerebral experimenting is going on; but it is well known that letting the mind play among facts has often led to magnificent conclusions. The solution is often reached first and the proof supplied afterwards.

For the collection of his facts, the geologist has to wander over the earth, often far from his home. He has to go to the seashore to learn about the erosion by waves, transportation by currents and deposition in quieter waters. There too he has to watch the process of entombment of fossils and formation of ripple-marks. He has to visit river valleys, gorges, rapids, waterfalls, brooks and even the roadside gutter for illustrations in dynamic geology, as also the hillside, the mountain slopes and elevated peaks where rocks are shattered by frost and decomposed under atmospheric agencies. Glaciers, caverns and underground channels have many special lessons to teach him. Deserts furnish him with illustrations of the mechanical work of wind, while pools and salt pans in arid regions tell him of chemical activities and precipitation of salts by evaporation. He has still other things to learn from springs, artesian wells, geysers, volcanoes and earthquakes. He studies representative collections of rocks, minerals and fossils in the laboratory first but he amplifies and correlates the knowledge thus gained by visits to the home of the rocks, where alone their larger relations

and their true significance in the history of the earth can be understood.

He walks, walks and walks and while doing so, broods over a multitude of geological facts; and broods deep enough to understand their meaning and significance. Imaginative thought has been the very life blood of the science. Geology, involving as it does long excursions into space and time, is a subject peculiarly fitted to stimulate regulated imagination, which is the very essence of the highest education. The dictum 'the past history of the globe must be explained by what can be seen happening now' or expressed more tersely, 'the present is the key to the past', has become the very cornerstone of geology, and it is a marvel of science that whereas historians have considerable doubt and difficulty in compiling an authentic history of human thought and endeavour between 5000 B.C. and 1000 B.C., geologists have been able to establish a connected and coherent history of the whole earth, its land-forms, its inhabitants, its climates, etc. through a period of hundreds of millions of years, so coherent that all scientists are agreed about it in all essential respects, albeit so astounding that even an ordinary educated man will look askance at many of the results, until he examines the evidence himself.

Contacts of geology with other branches of science.—It is true that in the family of sciences geology came of age at a comparatively late date, because it could not mature without the aid of sister sciences, but is it not also true that it has grown rather rapidly since then and has now established most beautiful contacts with them, often benefiting them in return? Think of its contact with astronomy, astro-physics, mathematics and celestial mechanics in tackling problems connected with cosmogony, origin of the earth, intensity and duration of solar radiation, precession, nutation, tides, shifting of the earth's poles, past climates, and so on. Think of its contact with physics in investigations connected with the age of the earth, radio-activity of rocks, viscous flow and isostatic equilibrium of the earth's crust, earthquake waves, nature of the earth's interior and prospecting for minerals by various geophysical methods. Think of its contact with chemistry in studying the composition and differentiation of magmas, phenomena of pneumatolysis, hydatogenesis, metasomatism, secondary enrichment, rock-weathering and the like. Think of its contact with biology in formulating and developing the grand conception of the origin and evolution of species, both animal and plant.

Some results of those contacts.—Is it surprising then that a large number of eminent scholars all over the world have been devoting themselves to the study of the numerous problems arising out of the contacts, which are often conflicts, between geology and other branches of science? These contacts have been the glory of science in two ways: they have enabled the

methods of investigation developed and the results obtained in one branch of science to be applied to the problems of another, thereby economising time and effort; and they have enabled the hypotheses put forward as a result of observations in one branch to be tested by the facts of another. This healthy process has helped science both to quicken its pace and maintain the universality of its truths. It is a bar against dogma based on a narrow set of facts.

Has not Wegener's captivating hypothesis of continental displacement been attacked seriously on palæontological grounds? Is not the controversy on the subject of the origin of the earth between the nebular hypothesis of Laplace, the planetesimal hypothesis of Chamberlin and the tidal theory of Jeans and Jeffries still going on because we are not yet sure whether the earth is heating or cooling, enlarging or shrinking? Has there been a bigger bone of contention between physics, mathematics, biology and geology for nearly half a century than the question of the most probable estimate of the age of the earth? Perhaps nothing in the annals of the nineteenth century physics made such an impression upon the sister sciences as this famous controversy between physicists and mathematicians on the one hand and geologists and biologists on the other. The deadlock was not resolved until the discovery of radio-activity which nullified Kelvin's fundamental postulate and allowed as much time as the geologists and biologists could require for the age of the earth.

And what better instance of the fruitful contact of geology with physics in recent years can I give you than the investigation of the nature of the earth's interior by means of natural earthquake waves? By a process analogous to that of revealing the internal architecture of crystals by means of X-rays, considerable light has been thrown on the nature of the earth's interior. Several of the results are in harmony with inferences otherwise reached, e.g. the basaltic substratum and isostatic equilibrium. Some others are novel, e.g. the 5000-mile diameter core and a regular layered structure between the core and the crust. Indeed we can say that the earth has been X-rayed. The method has been found to be so beautiful that artificial earthquakes are now being produced by means of powerful explosives, and hidden economic mineral deposits located by observing the paths followed by the vibrations within the earth's crust.

Applications of geology to industry.—Geology, like many other branches of science, has two aspects, the purely scientific and the practical or applied. The geologist who works in the pure science field does so primarily for the intellectual satisfaction derived from the discovery of facts and principles. His aim is chiefly to search for Nature's truths, irrespective of their bearing on human welfare; and his principal endeavour is directed towards widening the boundaries of human knowledge.

The chief aim of the practical geologist, on the other hand, is directed toward making the forces and materials of the world available to man, to augment the welfare of the human race, and to push forward the boundaries of civilization. But this work, important and noble as it is, can only be carried on successfully in proportion as the facts and laws of the pure science are discovered and understood. The worker in the applied side of the science has therefore to make his preparation in the pure science as broad and as profound as circumstances will permit.

Among the earliest problems, to the solution of which geological knowledge has been applied, are those of mining. Indeed, the science of geology developed in response to the needs of the miner for accurate knowledge of the conditions of occurrence, distribution and mode of origin of the valuable mineral deposits. Thus there have been developed the branches of coal geology, petroleum and gas geology, salt geology, and so on. Successful search for such deposits can only be undertaken by one well versed in the science of stratigraphy, including index fossils, and structural geology, while a thorough understanding of the principles of physiography and palæogeography is almost indispensable. The mining geologist who devotes himself primarily to the problems of the metallic deposits must have not only a thorough knowledge of mineralogy, petrology and structural geology, but of dynamic geology as well, and especially of the chemical and physical principles involved in ore deposition.

Geology also plays an important rôle in the solution of many engineering problems, e.g. construction of tunnels, canals, and water-works, and selection of sites for bridges, dams, and massive buildings.

Neglect of geology by Indian Universities.—It is a misfortune that a subject so eminently fitted for training the mind and body and so helpful in developing the mineral industry has been left out of their curricula by most of the Universities and Colleges in India. Ten out of the seventeen Universities have no courses of instruction in geology at all; two pay her a stepmotherly attention; and in none of the remaining five can geology be said to be a particularly strong department yet. The result has been that India's graduates have been the poorer in the kind of culture which is the special gift of geology, that Indian Universities have made no important contribution towards the major problems in geology, and that the mineral industry of India is only a fraction of what it should be. The neglect has also meant an overcrowding of graduates in the other branches of science and weakness in the teaching of geography in thousands of high schools in the country, for it is recognized that it is the graduate in geology that makes the best teacher in geography, especially physical geography.

The reason for this APATHY of the Indian Universities towards geology is not yet clear to me. It can well be made a subject of research ! It cannot be that the Universities do not know the importance of geology—so commonly is the subject found included in the science courses of Western Universities and so frequently do articles relating to the subject appear in the leading scientific journals. It cannot be that the Universities think that it is an expensive subject to provide for, because it is not so. The initial laboratory equipment necessary for imparting instruction in the subject upto the B.Sc. or the M.Sc. standard is less expensive than the corresponding equipment in nearly all the other science subjects. The annual recurring cost is also less, because specimens of minerals, rocks and fossils are neither used up in the process of study nor become out-of-date.

It cannot also be that the Universities think that graduates in geology will have no market value. In any case such an apprehension cannot apply to the B.Sc. course which is much more cultural than specialistic and, as I have indicated above, a large number of such graduates can be absorbed as teachers of geography in High schools throughout India. Where the geology courses are developed up to the M.Sc. standard and beyond, a certain number of graduates can be absorbed in the educational line, as is the case with the other sciences at present, a certain number in Government departments and in the Indian States, and a certain number in private mineral surveys. We must begin to think of a developed India, of provincial geological surveys, of scientific prospecting, and of a greater interest of the general public in geology, both pure and applied.

Some suggested remedies.—It is high time that something was done to bring home to the Indian Universities the claims of geology. I wish a committee of the leading geologists in India, who substantially agree with the above views, were to draw up a memorandum on the subject, including a detailed scheme showing, on a modest scale, the accommodation, staff and equipment that would be needed for an undergraduate and a post-graduate course, and send it to those teaching Universities and those constituent colleges of the examining Universities in which provision has not yet been made for geology. Failing such a committee, I wish a committee of the Indian Science Congress would take up the matter. And if that also is not possible or convenient, I wish the Inter-University Board could be moved to interest itself in the matter. In either case, a simultaneous agitation should also be led through the public press.

The assistance of the Government of India should be sought at least to the extent of presenting to the Universities and Colleges that take up the teaching of geology such sets of Indian minerals, rocks, fossils and publications as the Geological

Survey Department can spare. If they are agreeable, a note to that effect should be included in the memorandum suggested above. The Education Departments of the various Provincial Governments should also be approached with a request to adopt and announce a policy of giving preference to graduates in geology for the posts of geography teachers in schools. And if they agree, a note to that effect should also be included in the said memorandum.

If the Universities accept the proposal, I know that other questions will crop up. For instances, whether geology should be introduced in the B.Sc. course only or in the Intermediate course also ; if the former, whether there should be a preparatory course of Physical Geography—also called Physiography—in the Intermediate class ; what previous qualifications should a candidate for geology possess ; what would be the suitable groups of subjects for the Intermediate and the B.Sc. examinations. But let us not worry about this further stage. Let us be content now with the installation of the image of the Goddess of the Earth in our Temples of Learning.

II. ORGANIZATION OF INDUSTRIAL MINERAL RESEARCH IN INDIA.

Economic minerals and their international control.—Let me pass on now from the academic to the economic aspect of geology. Our civilization is shaping along lines that make the use of metals and fuels more and more necessary. Indeed iron, steel, copper, coal and petroleum are considered indispensable and there is a large number of other mineral products of varying degrees of usefulness. So rapid have been the demand and supply that the world has used more minerals during the last quarter of a century than during all previous history.

Nature has distributed minerals very unequally over the earth. Some kinds of minerals are distributed so widely that nearly all countries have adequate supplies within their own boundaries or near at hand. Other kinds are so distributed that some parts of the world have a surplus and others a deficiency. Still others are confined to a few localities only. No country in the world is entirely self-sufficing as regards either supplies or markets for all its mineral commodities—not even the great U.S.A. whose annual mineral production is now two-fifths of the whole world, nor mighty Britain.

The logic of this position would appear to be that if the mineral industry of the world is to be developed on sound and economic lines, consistently with the growing ideas about civilization, mineral commodities must flow from one country to another, as required, according to the surplus and deficit positions, either in crude or manufactured forms.

Such international movements of minerals and mineral

products may be aided or hindered by bounties, rebates, tariffs, preferential duties, and embargoes. These measures may be locally and temporarily desirable for several reasons, but if made general or permanent, are likely to lead to friction in international relationships and interference in the orderly development of the mineral industry. When, for instance, it is desired to develop an important infant mineral industry by means of tariff protection, the geological and other factors of the situation must be carefully considered; and protection should not be resorted to unless it is satisfactorily shown that the industry would be ultimately able to stand on its own legs, i.e. face a world competition unaided.

Another axiom of the mineral industry should be that minerals should be concentrated, smelted or fabricated near the sources of supply, whenever conditions permit. Countries fortunate enough to possess large supplies of a needed mineral, deficient elsewhere in the world, are entitled to the benefits that may accrue from its conversion and fabrication. Such local treatment would give employment to a section of the population, decrease the cost of export through reduction of weight and hence give an added chance, in some cases the only chance, of competing in foreign markets, and ensure a supply of the manufactured commodity for the internal needs of the country. Coal is the chief source of energy required for such work; and experience has shown that many minerals can be utilized with greater efficiency near the source of the coal than near the source of the minerals.

The mineral industry of the world was progressing smoothly along the above sound lines, when a rude shock was given to it by the Great War. Many established channels of international movements of minerals were seriously interfered with, if not blocked altogether. Many countries, whether belligerent or not, had to fall back on their own meagre supplies of certain minerals, developing the resources at excessive cost, and had to do without some minerals altogether. Indeed, serious attempts were made to bring the foe to his knees by cutting off his supplies of certain essential minerals—a mineral blockade. It is now 14 years since the War was over but the hardships caused by the dislocation of the mineral industry during the war do not seem to have been forgotten. None of the leading nations seem to be believing now that the last war ended war. In fact they seem to be smelling another conflict at no distant date, as judged from their post-war mineral policies.

In spite of the facts of the unequal geographical distribution of minerals, each of the war-minded nations is now attempting to make itself self-sufficient at any cost as regards its anticipated mineral needs in time of war. The exploitation of poor deposits resorted to under war duress is being continued with the help of heavy tariffs, subsidies, etc., although the minerals are cheaply

available again from other countries where there is a surplus. Diligent and expensive search even under adverse geological circumstances is being made for minerals the supply of which may be cut off during the next war. France, for example, in the face of an overwhelming world surplus of manganese, is now developing new deposits in her North African territories. For the same motive, the American manganese industry is being maintained through the aid of a heavy tariff. England is now building copper refineries in England to treat Rhodesian blister copper, in the face of a huge world surplus of copper refineries. France is building up oil-refinery capacity through licensing of imports, with agreement on the part of the licensee to build a refinery. She is also forcing oil development in Iraq.

The net result of these over-developments of minerals is waste—physical waste of raw materials and equipment, economic waste, employment waste, social waste. How long can it last? For two decades before the war, the curves of mineral consumption were rising rapidly and steadily. Since then, there have been wide fluctuations but when they are averaged, a general flattening is noticed, except in the case of oil. On the top of this have come the new political theories of property control in Russia. Under the first Five-Year-Plan, the mineral production has been forced to over twice its previous value. And another similar advance is sought under the second Five-Year-Plan, regardless of the fact that some of the minerals occur in plenty elsewhere in the world and can be more cheaply imported in the raw or manufactured form than locally produced.

When shall we realize again that Nature's distribution of raw materials cannot be changed by enactments, and that it calls for a reciprocal exchange among the nations to their mutual advantage?

What lesson has all the above for India? Our mineral resources are vast and varied but our production small. Our area is one-thirtieth and our population one-fifth of the world but our annual mineral production is only one-fiftieth of the world by weight and one-hundredth in value, approximately. We are largely exporters of raw minerals or semi-finished products and importers of finished products. Other countries can give us a slap on the face by shutting out, by means of tariffs, even our developed minerals and semi-finished products like manganese and pig-iron of which we have a surplus, and yet we must go to them, with folded hands, with other minerals like mica which they need and of which we are the world's principal producers, but which we are unable to use ourselves. Is it not time that we set our house in order? Is it not time that we concentrated, smelted or fabricated for our own use such of our own minerals as we have in plenty and for which we possess facilities? Is it not time that we offered for export

some of the minerals, of which we possess large supplies, in manufactured forms?

It is gratifying to find that Mr. Tipper, late of the Geological Survey of India, has analyzed the situation in detail in a paper on 'Recent Mineral Developments in India' read before the Royal Society of Arts in London in February, 1930; and that Sir Edwin Pascoe, the recently retired Director of the Geological Survey of India, has given a masterly survey of the subject in a lecture on 'The Mineral Wealth of India: its Present and Future Developments', delivered at the Imperial Institute, London, in March, 1931. One would wish that such lectures were delivered from time to time before Indian scientists, technologists, and businessmen in India, and were followed by profitable discussions. I take the liberty of quoting the following passage from Sir Edwin's lecture:—

'Surely it is wrong that the concentrates of zinc sulphide from Bawdwin should be shipped to Belgium for smelting and the zinc and sulphur imported back again separately. Where is the red and white lead industry which one would expect to find in collaboration with this mine? Why should it be necessary to import annually even the small quantity of 2,400 tons of lead in the form of manufactured articles? Why is the soft coke industry so insignificant? Why is most of the manganese ore exported in the raw state instead of in the form of ferro-manganese? Would competition with the Malaya States make it impossible to smelt the tin of Tavoy and Mergui on the spot and ship it from almost adjacent harbours? Why is a valuable manure like saltpetre exported to increase the tea crop of Ceylon or to amuse other nations with fire-works? The glass industry is expanding, but India's daughters still spend some £850,000 each year on imported glass bangles and beads, although there are adequate supplies of sand suitable for glass-making in the country itself. Is it right that the annual value of the imports of glass-ware exceeds £1,800,000 and that more than half of it should come from Japan and Czecho-Slovakia? How long will it be before India ceases to import steel articles and begins to supply the world with the same instead? How long will it be before this industry absorbs more of the Indian chromite, tungsten, manganese, and perhaps magnesite? Is the transport question the critical factor in making it cheaper to import annually £58,000 worth of Italian and Grecian marble instead of buying equally beautiful material in Rajputana, or is it the more systematic organization of the European quarrying operations? Is not the manufacture of paints capable of expansion? Will agriculturists awake soon to the value of the extensive phosphate deposits in Bihar and in Trichinopoly, which,

in face of the present low demand, it scarcely pays to work ?'

And there are many other problems of a like nature which await solution.

Purpose and importance of industrial mineral research.—Industrial mineral research is research which has for its object the application of science in searching for, winning, concentrating and fabricating economic minerals for the uses of mankind as cheaply as possible. It is well known what strides pure science has been making in discovering the properties of matter. Although the primary aim of the scientists has been knowledge for its own sake, it would be a double gain if the knowledge could be applied to augment human happiness. Some one has therefore to experiment and find out how best this could be done. We call this Applied Science.

There was a time when applied science was treated with a certain amount of disparagement, as being an attempt to adapt science to commercial purposes, a means of increasing wealth rather than of increasing knowledge. It was held to be a merit that Universities concerned themselves only with knowledge for its own sake. But this narrow outlook has almost disappeared. Even Oxford and Cambridge are now taking a prominent part in the advancement of applied science. It is recognized now that applied science is but an investigation in the laboratory of the processes which are involved in the adaptation of Nature to the service of society. The application of science is a process of science, as much as the discovery of the laws sought to be applied for the service of man. Nor can it be said that applied science presents less difficult problems. And just as discoveries in pure science lead to new developments in applied science, achievements in applied science often give suggestions for further investigations in pure science. To realize the importance of industrial research in the mineral field, one has only to think of the geophysical methods of prospecting, the froth flotation methods of ore-dressing and the hundred and one economies in the methods of using coal.

How such research is carried out in foreign countries.—Industrial research is considered to be of most vital importance in almost every country of the West. Armies of scientists and engineers are employed in its pursuit and tons of money spent, or rather invested. The return must be good, as judged from the fact that there is a greater and greater demand for such activity.

The U.S.A. now leads the world in industrial research, including mineral research. First of all, there are the manufacturing firms. Each of the larger firms has its own research establishment. The number of firms which spend from £10,000 to £100,000 per year on research work is quite large. In many cases, a miniature of the actual works plant is erected in the

research laboratory, on which the research staff tries improvements. The opposite is also done, viz. a miniature plant for a new process is first built and developed, preparatory to its full-size construction. Pure science investigations are also undertaken. Then there are associations of smaller manufacturers, such as those of lime manufacturers, tile manufacturers, brick manufacturers, etc. having joint research laboratories. Then there are the Universities and Colleges, where a great deal of industrial mineral research is nowadays carried out. Then there is the Mellon Institute at Pittsburg, founded specially to provide manufacturers with the services of a great scientific laboratory, and trained staff, for the investigation of problems arising in their industry, at an expenditure far less than would be involved in the establishment of their own private laboratories. Manufacturers are encouraged to submit their problems and when these involve considerable research, are required to pay for one or more research assistants' wages for the period required by the investigation. There are about 40 separate laboratories in the Institute, each providing for one or two research workers at a time, and each having complete facilities for chemical and physical testing, etc. The results of researches are not published until three years after their completion, except by consent of the manufacturer. At the conclusion of a research, it has become usual for the manufacturer to secure the services of the research assistant or assistants who carried it out, and thus the highest positions in industries tend to become filled by men of sound scientific value. In almost all cases researches have been successful and many have resulted in considerable financial returns to the industry concerned. (How one would wish that the Tatas had founded, or would found now, such an industrial research institute also; or that the trustees of the estate of the late Mr. D. Laxminarayan of Nagpur would found such an institute for industrial mineral research, considering that he made his fortune in the manganese mining industry.)

Next, there are the great U.S.A. National Institutions—the Geological Survey, and the Bureau of Mines. They have magnificent research laboratories, employ an army of trained workers, cover a great variety of industrial mineral problems, do excellent work, prepare lucid and well-illustrated reports, distribute them gratis to a large number of selected persons or parties, and only at the cost of printing and paper to the general public. The number of publications bearing on the mineral industry is much larger than those on pure geology. In addition to all these, in the U.S.A., there are many commercial research laboratories, i.e. private firms undertaking research. In short, industry is considered to be the very basis of national prosperity, and every resource is made available to facilitate its progress. Research is regarded as an indispensable weapon with which to meet international competition.

In most of the European countries, notably Germany, England, and France, and now Russia also, the industrial mineral research position is similar, though not so strong as in the U.S.A. In 1918, i.e. the year in which the great war was over, England set apart one million pounds sterling and established the Department of Scientific and Industrial Research, which has now got many branches and sections and has done a great deal of useful work.

Position of the question in India.—What shall I say of the position of industrial mineral research in India, except that it is *non est*? The companies engaged in the mineral industry have no research departments worth mentioning—not even the Tatas. The position of the Universities and Colleges with regard to geology, pure and applied, has been laid bare in the earlier part of this address. Of commercial laboratories, there are none in the country. There is not even a dealer of Indian or any minerals in the length and breadth of the land. The Department of Mining and Metallurgy of the Benares Hindu University, started in 1923, and the Indian School of Mines and Geology at Dhanbad, started in 1926, are still too young and have not been endowed for research. The Government Department of Mines only issues an annual statement of mineral production and an annual catalogue of accidents in mines. The only body that does something of industrial mineral research, and that can, and should, do a great deal more, is the Geological Survey of India, the oasis in the desert.

The Geological Survey of India.—The Geological Survey of India started by the Government in about the middle of the last century has been singularly fortunate, or rather the country has been fortunate, in attracting to its service a long series of men of very high calibre, most prominent among whom have been—Medlicott, Blanford, Oldham, Holland, Middlemiss, Hayden, and Pascoe, the present staff apart. The Survey has maintained throughout a high standard in the quality and quantity of its scientific work, and its publications enjoy an international reputation of no mean order. Many of its officers have made outstanding contributions towards some of the major problems of geology. It can safely be said that the foundations of Indian stratigraphy have been well and truly laid, that a fairly accurate general geological map of the whole country has been prepared, that many localities have been studied in sufficient detail and that several monographs on particular economic minerals have been carefully compiled. It is also true that the Survey has built up an excellent library and an excellent museum of rocks, minerals, and fossils at Calcutta.

But is not all the above only a means to an end? Was not the Survey brought into existence really for the purpose of helping in the development of the mineral INDUSTRY of India? Does the Survey think that as its scientific reports

are before the public, anybody can read the few short paragraphs on 'Economics', given in woolly language at the ends of many of them, and thereupon go and start mineral industries; and if they do not, or having done so, burn their fingers, the Survey has not to worry about it? Knowing the state of the geological knowledge of the general public, is it not time that the Survey did something to educate public opinion in the matter of mineral development? Knowing the lack of facilities for industrial mineral research in the country and the handicaps of Indian capitalists, is it not time that the Survey did something more for the public than by giving advice and identifying minerals free of charge? Is there not a large number of problems confronting the Indian mineral industry to-day, which appear to be capable of a satisfactory solution by the co-operation of science and industry? I think it is high time that the policy of the Geological Survey of India was reviewed or a separate mineral research department established.

Some important problems.—It is impossible, within the compass of an address like this, to discuss the many and varied problems that beset the path of India's mineral industry to-day. A short but thought-provoking list has been given in the eloquent passage quoted from Sir Edwin Pascoe's lecture.

Suggested methods of tackling the problems.—The crux of the situation is—how are we going to tackle these problems? It is a pity that neither Mr. Tipper nor Sir Edwin, both of whom have drawn vivid pictures of the existing position in their London lectures, has put forward his views about amelioration. I wish they will do so even now. My own suggestion is—organize industrial mineral research as soon as possible; make a five-year-plan. The suggestion might possibly draw a volley of questions and objections such as these: Who will make the researches? Where will they make them? Who will pay for them? Will it be worth while to make them? Is the Indian capitalist likely to benefit by them? If new mineral industries crop up like mushrooms as a result of these researches, how will you man them? Will it not be better to wait until the present acute trade depression is over and then proceed slowly and cautiously? Will tariff protection be forthcoming for any such new industries if necessary? And so on. Let me anticipate such questions and try to answer them.

Taking stock of the whole situation outlined in the foregoing remarks, the conviction is clear to me that the Government of India must take the initiative in the matter of mineral research, as they have recently done in the matter of agricultural research. They may, if they like, create an independent mineral research department; but it appears to me that there are many and valuable advantages in making use of the excellent resources of the existing Geological Survey department, now 80 years old. It is deplorable that this nation-building department

has had nearly half its staff retrenched away in one sweep last year, in spite of the protests of some of our leading scientists like Sir C. V. Raman. I do not know why the protest was not more general; possibly because people thought that the Survey only made maps, and not money. However that may have been, it appears to me to be eminently fitting that the present cadre of the Survey be reserved for continuing the kind of work they have been doing all these years, and that a whole parallel branch of at least fifteen officers be added specially for industrial mineral research work, under a common Director. An initial grant of twenty lakhs of rupees, distributed over five years, should be made by the Government of India for a new building and research equipment. The headquarters should be at Calcutta. The running expenses should be met partly by a Government grant which must cover the salaries of the fifteen officers, partly by a cess on the output of minerals in India and partly by contributions from those parties whose special problems are investigated. A cess of half a pice per ton of coal raised would amount to about Rs. 1,50,000 per year. An *ad valorem* cess on other minerals would bring a further Rs. 3,50,000 per year, making a total of Rs. 5,00,000. From this may be deducted Rs. 1,00,000 on account of exemption of certain minerals from the cess and the cost of collection, leaving a net estimated income of Rs. 4,00,000 per year. The income from contributions from particular parties, whose special problems are investigated, would be variable and cannot be estimated at present, but it does not matter because it would be largely compensated by increased expenditure on the special researches concerned.

The plan of campaign should be somewhat along the lines of the Mellon Institute in the U.S.A., referred to in the earlier part of this address, with this important difference that whenever the staff was not occupied with any special investigations required by the public, it should pursue the Geological Survey's own programme of industrial mineral research, decided upon by a committee on which there should be an adequate representation of the cess-payers.

The co-operation of Indian Universities and other institutions such as the Indian School of Mines at Dhanbad, the Indian Institute of Science at Bangalore, the Government Test-House at Alipore, the Metallurgical Inspectorate at Jamshedpur, etc. should be sought as fully as possible. That is, whenever it appears that any particular problem in hand can be satisfactorily investigated at any of those places, and if they are willing to take it up, it should be sent there and an appropriate grant made to it for the purpose, thus leaving the special staff of the mineral research branch of the Geological Survey free for other work.

An attempt should simultaneously be made to educate the

public by (1) writing and publishing a book on general geology, taking instances and illustrations from India; (2) ditto on economic geology; (3) compiling a set of the provincial geologies of India; (4) bringing up to date or rewriting the last, i.e. the 1893, edition of the excellent 'Manual of the Geology of India' by Medlicott, Blanford, and Oldham; (5) reprinting as many of the out-of-print *Records* and *Memoirs of the Geological Survey of India* as were in demand, or were likely to be in demand, in a revised form; (6) bringing out an extensive series of pamphlets, booklets, manuals, etc. on various aspects of Indian geology, both pure and applied, in popular language and well illustrated, and distributing them at the cost of paper and printing only; (7) improving the condition of the geological sections of the various provincial museums.

The staff of the mineral research branch of the Geological Survey should include three economic geologists, who should be specialists in ore minerals, non-metallic minerals, coal, and oil, two mining engineers for ore and coal, two metallurgical engineers, ferrous and non-ferrous, one ore-dressing expert, one mechanical engineer, one electrical engineer who has specialized in electric furnace work, one chemical engineer, one combustion engineer otherwise called fuel technologist, one chemist, one physicist, and one industrial economist.

The equipment should include several types of geophysical prospecting instruments, miniature units of all standard ore-dressing appliances, a set of small coal-fired, oil-fired, gas-fired and electric furnaces of various types and ranges, with accessories, a set of testing instruments, such as are not possessed by the Government Test-House at Alipore, a metallographic outfit, a mechanical workshop, an electrical workshop, low-pressure and high pressure compressors, soil-testing outfit, road-metal testing outfit, plants for pulverising and lixiviation, small cast-iron, steel and non-ferrous foundries, and many sets of the ordinary chemical and physical apparatus.

Thus organized, manned and equipped, do you think there is a risk of the capitalists not making use of, or profiting by, the facilities? Do you think there is a risk of the Government not protecting any resultant mineral industry, if they were satisfied that we possessed natural advantages for it and that it was likely to stand on its own legs after a period? Do you think that the results obtained will not be commensurate with the effort? I think not.

Nor is there any danger of not being able to find sufficient trained men to work any new mineral industries developing. Until the Universities of India realize their duty in the matter, foreign-trained experts will have to be employed. But once the channel is established of the manufacturers taking up in their service the very research assistants who helped in solving their technical problems, all will be well.

And as regards the present acute trade depression, I see in it a further reason for launching a scheme of industrial research now. The very object of the scheme is to promote industries, and thereby to relieve depression. Was not the great one million pound research scheme started in England in the very year in which the Great War ended, and when the finances of Britain were presumably at their lowest ebb?

And lastly, I have suggested a five-year-plan only because I think that some such time limit gives a greater vigour and a greater definiteness to our determination to achieve a goal, than otherwise. Our every-day life would seem to furnish many illustrations of this.

Gentlemen, I have done. I have placed before you some of the uppermost geological thoughts of a mining and metallurgy man. I do not claim that the scheme of industrial mineral research outlined by me is the only one or the best one that could be devised. My object is to focus public attention on this important and urgent question. My desire is that other heads, wiser than mine, should devise better schemes, which would enlist greater support of the public and the Government, and having devised them, work for them until the goal is achieved.

Section of Geology.

Abstracts.

MINERALOGY.

1. Felspars in the amygdales of the Lingadhalli traps.

CHARLES S. PICHAMUTHU, Bangalore.

In a previous communication to this section of the Congress, the author came to the conclusion that the spots and patches found in the trap rocks of Lingadhalli are metamorphosed amygdales. A detailed examination of the mineral contents of these amygdales has now revealed the presence of a colourless mineral with a radiating habit and exhibiting multiple twinning. Staining tests, specific gravity, and refractive index measurements, and a study of its optical characters by means of the Fedorov Universal Stage have resulted in the identification of the mineral as a plagioclase of composition $Ab_{65}An_{35}$ (anoclase).

2. On the occurrence and distribution of staurolite in Gangpur State, Bihar and Orissa.

M. S. KRISHNAN, Calcutta.

Staurolite occurs in mica-schists (1) in a zone parallel to and adjoining a large epidiorite sill extending from Gailo ($22^{\circ} 4' : 84^{\circ} 44'$) to Rabga ($22^{\circ} 4' : 84^{\circ} 29'$), (2) along the borders of some granite bosses, and (3) apparently unconnected with intrusives, as along the centre and borders of the Gangpur anticlinorium. The crystals show the development of m (110), b (010), c (001) and r (101); *plus*-shaped twins on (032) where the individuals cross at right angles, X-shaped twins on (232) crossing at nearly 60° , and six-rayed trillings also twinned on the pyramidal face.

The rocks of the area show clear evidences of regressive metamorphism from the *meso* to the *epi* grade. The regional metamorphism to which the area was subjected seems to have been sufficient for the formation of staurolite, but the intrusive rocks have helped to perfect the conditions by raising the temperature and increasing the molecular mobility in their neighbourhood.

3. Microscopic characteristics of the copper ores of Singhbhum.

M. C. PODDAR and S. K. ROY, Dhanbad.

This paper deals with the paragenesis of copper ores of the Mosaboni mines, Singhbhum, as revealed under the metallographic microscope. During the investigations it was found that, in the sequence of deposition, pyrite was the first formed mineral, after that came pyrrhotitic solution and chalcopyrite was formed last of all. Several microphotographs of the paragenesis are included in this paper.

PETROLOGY (IGNEOUS).

4. On the occurrence of an uralitic gabbro near Vajrat, Sawantwadi State.

K. V. KELKAR and R. D. GODBOLE, Poona.

The rocks forming the hills to the south of Vajrat, about six miles north-east of Vengurla, were found to vary between a gabbro and an uralitic gabbro containing plagioclase and uralite. In thin sections the gabbro exhibits plagioclase, augite (in part diallagic), and a little orthorhombic pyroxene. The accessories are magnetite and biotite. The augite has slightly altered to secondary amphibole at the margins. Confused aggregates of magnetite grains and colourless secondary amphibole, showing a ring of green amphibole where in contact with plagioclase, have probably resulted from original olivine. Pink garnet also occurs as a corona mineral, either alone or with green amphibole. Commonly the rocks are dark and have a medium-grained granitic texture. The rock is intrusive in an Archæan granite-gneiss and some quartzites of uncertain age.

5. A note on some basic intrusions in South Belgaum District.

W. K. PATWARDHAN, Poona.

The paper contains a description of several dolerites intruding the granite-gneiss and Dharwars in South Belgaum District. They are dark coloured and have a fine to medium-grained texture. Two types are common: some contain augite, plagioclase, a little biotite and magnetite, the quartz forming micrographic intergrowth with plagioclase; other equally common types contain magnetite and biotite as accessories, and olivine, enstatite, augite and plagioclase. A single compact basaltic rock was found. It contains phenocrysts of augite, enstatite and decomposed olivine. In the groundmass are commonly seen untwinned plagioclase needles forming fan-like groups, and augite, biotite, and magnetite.

6. On the petrography of the porphyry dykes near Mandya.

S. RAMACHANDRA RAO and CHARLES S. PICHAMUTHU,
Bangalore.

The paper is a petrographic study of two types of porphyritic dyke rocks occurring about 6 miles to the south of Mandya. One of the dykes is a monzonite porphyry containing phenocrysts of orthoclase, plagioclase, and hornblende. The orthoclases, which are flesh-coloured, occur in very well-formed crystals, many of which are found loose in the weathered portions of the dyke. The groundmass is composed of a panidiomorphic aggregate of plagioclase. The specific gravity is about 2.61. The other dyke contains porphyritic crystals of plagioclase, hornblende, and biotite set in a fine-grained felspathic matrix. Many of the phenocrysts of plagioclase show well-defined zoning; quartz occurs sparingly in irregular grains. The specific gravity is about 2.68 and the rock may be described as a tonalite porphyry.

7. On the corundum-bearing rocks in the Namakkal Taluk, Salem District, Madras Presidency.

L. A. NARAYANA IYER, Calcutta.

The rocks referred to in this paper are found south of Sittampundty. Mr. C. S. Middlemiss has published a note on these corundum rocks in

Rec. Geol. Surv. Ind., XXIX. The present paper deals with the suite of rocks associated with them.

The corundum rock is a pale grey or white anorthite-gneiss, with varying amounts of hornblende and with accessories as garnet and some chondrodite. The corundum is surrounded by a lighter coloured shell of felspar. The anorthite-gneiss is accompanied by a series of intrusives varying from ultrabasic, basic and acid. These different intrusions suggest that there has been a differentiation and fractionation of a basic magma in this area, which has given rise to the large exposures of anorthite-gneiss, in which the other members are intrusive.

The ultrabasic fraction is represented by a chromite-pyroxene rock, the basic by a garnet-pyroxene-plagioclase-rock with synantetic intergrowths round the garnets, and the acid by pegmatite dykes and quartz veins. The evidence obtained from this suite of rocks suggests that there was an oversaturation in the anorthite portion of the magma with alumina, which subsequently crystallised out as corundum.

PETROLOGY (SEDIMENTARY).

8. The graphical representation of heavy mineral analyses.

P. EVANS, R. J. HAYMAN, and M. A. MAJEED, Digboi, Assam.

The accessory minerals of arenaceous rocks have received much attention in recent years as it has been found that valuable aids to correlation can sometimes be obtained by a comparison of the minerals from different areas. Attention is usually concentrated on the heavy residues obtained by separation with bromoform but there is no general agreement either as to the manner in which the analyses of the minerals should be carried out or as to the manner in which the results should be represented.

The relative abundance of different minerals may be obtained either by rough estimation or by careful counting and may be indicated by symbols, by an arbitrary scale from 1 to 9 or 10, or by percentages. Except in very simple cases, it is almost impossible to tabulate the results in such a way as to bring out clearly the differences between the mineral suites of different localities and horizons. The successful application of the micropetrological method depends largely upon the readiness with which the available data can be compared and graphical methods have a very great advantage over tabulation. The geologists of the Burmah Oil Company have worked out a graphical method of representation of accessory mineral analyses which has been of great use in Assam. The stratigraphical position of each sample from any particular section or locality is plotted horizontally on squared paper and the mineral frequencies are plotted vertically using a special scale which is nearly logarithmic (i.e. geometrical progression). The paper includes three examples of such 'range tables'.

9. The graphical representation of mechanical analyses of sands.

P. EVANS, W. B. METRE, and B. H. SINGH, Badarpurghat, Assam.

The detailed examination of a sediment includes the estimation of the proportions of grains of various sizes, which (for sands) is most conveniently done by the use of sieves. The technique of such mechanical analysis is very simple, but the representation of the results often fails to bring out clearly the differences and resemblances between a number of samples.

There are two usual methods, the cumulative percentage curve and the histogram. In the former, the grade size is plotted horizontally,

usually on a logarithmic scale, and the cumulative percentages by weight of the various grades are plotted vertically, so that each curve runs from 0 on the left to 100 on the right, differing in slope according to the composition of the sample. The drawback is that the distribution of grains between different grades is not sufficiently clearly shown. The histogram consists of a series of rectangles with lengths proportionate to the percentages of grains within definite grades—usually not of equal range but in geometric progression. The drawback is that only one sample can conveniently be shown on one figure and the varying range of diameters may make comparison difficult.

The method used by the writers overcomes these objections. From the cumulative percentage curve plotted on ordinary (not logarithmic) paper the first differential is obtained graphically by subtracting successive points on the cumulative curve for intervals of, say, 0.05 mm. This gives a curve showing the percentage of each 1/20 mm. grade of sand. Several curves can be drawn on one sheet and comparison is greatly facilitated. The paper includes several examples of these curves.

10. The heavy minerals in the Barakar and Raniganj Series of the Jharia Coalfield, Bihar.

M. C. PODDAR, Comilla.

(Communicated by P. Evans.)

The heavy mineral residues of over a hundred samples of sandstones in the Barakar and Raniganj Series of the Jharia Coalfield have been separated by bromoform and analysed.

The assemblage found in the Barakar Series consists mainly of magnetite, ilmenite, zircon, rutile, and tourmaline. The Raniganj assemblage consists mainly of garnet with much smaller amounts of magnetite, tourmaline, and zircon and very little rutile. There is thus a clearly marked difference between the two mineral suites, enabling the series to be distinguished.

From the analyses and stratigraphical position, range-tables have been drawn out on the lines devised by the Burmah Oil Company's geological staff. Although the sampling was not carried out at very close intervals, the range-tables for six different sections show a fair measure of correspondence. The Barakar Series can be subdivided into four unequal stages on the basis of the variations in tourmaline and zircon: these are not very striking but are probably recognisable throughout the Jharia field. It is not improbable that with more detailed work, micropetrological evidence would be of assistance in correlating the different seams.

PETROLOGY (METAMORPHIC).

11. The origin of the streaky gneisses of the Nagpur district.

W. D. WEST, Calcutta.

Associated with the metamorphic rocks of the Nagpur district known as the Sausar series, there occur large areas of coarsely banded 'streaky gneisses' which, treated as a whole, bear a discordant relation towards the Sausar series. From certain favourable exposures on sheet 55 $\frac{1}{2}$, which show these gneisses in the early stages of formation, evidence is adduced to show that they have in the main been formed by the intimate penetration of a biotite-granulite of igneous origin by veins of aplite on an immense scale. In some cases the para-schists of the Sausar series have likewise been penetrated to give streaky gneisses difficult to distinguish from those of wholly igneous origin.

It is concluded that there was first an intrusion of large masses of granodioritic magma, followed soon after by the intrusion of a more acid aplitic magma, which penetrated both the granodiorite (now a biotite-granulite) and the schists of the Sausar series in a very intimate manner, giving rise to banded gneisses of composite origin.

12. On some Dharwarian conglomerates from Chota Nagpur and Jubbulpore.

M. S. KRISHNAN, Calcutta.

There are several occurrences of crush-conglomerate in Gangpur State, Bihar and Orissa, and in the neighbourhood of Sleemanabad ($23^{\circ} 38' : 80^{\circ} 15'$) in the Jubbulpore district, C.P. In the Gangpur area the conglomerates include gritty, crushed, and sheared types, containing pebbles of quartz, quartzite, biotite-schist, tourmaline-quartz-rock, and rarely granite. In the Jubbulpore area the pebbles are of quartzite, cherty quartz, and banded hæmatite-quartzite. The matrix generally contains quartz, mica, sericite, chlorite, and magnetite.

In some cases the pebbles are large and well-rounded and in others sub-angular and distinctly crushed. All gradations from rocks which may be considered to be clearly sedimentary to those which may be called autoclastic are met with. The author is of opinion that practically all the conglomerates studied were originally of sedimentary origin, but crushed and sheared later, though locally true autoclastic conglomerates might have been produced.

13. A preliminary account of the metamorphic rocks of the Darjeeling area.

SANTOSHKUMAR RAY, Calcutta.

In 1902 Mr. J. Parkinson described the petrography of the Darjeeling series of Mr. Mallet, and established the presence in it of a garnetiferous sillimanite-gneiss and an 'eye' rock, viz., a quartz-garnet-pyroxene rock. In the present paper, which includes a description of a wider area, a few additional types of rocks of the Darjeeling series have been described, viz., a garnetiferous kyanite-gneiss, kyanite-sillimanite-biotite-gneiss, a felspathic mica-schist with tourmaline and staurolite-bearing varieties, and a quartz-felspar-garnetsillimanite rock. This paper also includes the description of a tourmaline-bearing phyllite and a garnetiferous phyllite, which form part of the Daling series of Mr. Mallet. The presence of staurolite in some of the rocks has been noted here for the first time. Representatives of the gneisses, schists, and the phyllites have been analysed chemically. The agreement in chemical nature between the gneiss and the schist has been pointed out, and a para-metamorphic origin has provisionally been ascribed to the rocks from a study of their chemical, mineralogical, and field characters.

14. Geology of the country around the Indian School of Mines, Dhanbad.

O. L. DADHEECH and S. K. ROY, Dhanbad.

In this paper the authors deal with the geology of an area of about 30 sq. miles around the Indian School of Mines. On classifying the rocks of this area according to Grubenmann, it was found that members and groups I, II, III, IV, V, VIII, and IX of Grubenmann's classification are represented in this area. All of them are fully described macroscopically and microscopically and some of them are analysed. The paper includes a $4''=1$ mile geological map of the area specially prepared for the purpose by one of the authors.

STRATIGRAPHY AND PALÆONTOLOGY (ARYAN).

15. A note on the Cullygoody limestone.

L. RAMA RAO and C. PRASANNAKUMAR, Bangalore.

The Cullygoody limestone, so called because of its abundant occurrence north and south of the village of Cullygoody, forms one of the most important bands of coral limestone associated with the Trichinopoly Cretaceous. A brief descriptive account of this rock is given by Blanford (*Mem. Geol. Surv. Ind.*, IV). He has also discussed at some length the age of this limestone and has adduced several arguments in support of its being considered as of the same age as the coral limestone at the base of the Utatur beds. The Cullygoody limestone has now been studied by the authors, both in the field and in the laboratory. Though the rock may generally be described as a coral limestone, the study of a large number of micro-sections has revealed the additional occurrence of numerous interesting types of Microzoa—chiefly foraminifera and radiolaria. But by far the most important feature of the fossils in this limestone is the occurrence of numerous algæ, particularly in one type of this limestone. Considering that this bed is of Utatur (Cenomanian) age, it is obvious that this occurrence of Cretaceous algæ in India is even older than that in the Niniyur rocks.

16. On the flints and cherts of the Niniyur stage.—III.

L. RAMA RAO and C. PRASANNAKUMAR, Bangalore.

The paper deals with an intensive study of the several bands of flints and cherts round about the village of Vilangudi, a brief reference to which has been made by Blanford in his Memoir on the Trichinopoly Cretaceous. A large number of representative specimens has been collected and studied both in hand specimens and in micro-sections. It has thus been possible to distinguish several types of these flints and cherts, on micro-structural and palæontological considerations. A point of great interest and importance is the occurrence of numerous algæ—chiefly *lithothamnion*—in many of these types. The important question of the exact age and mode of origin of these flints and cherts is briefly discussed, in the light of the new evidences now available.

17. On the age of the Quilon bed.

A. K. DEY, Calcutta.

The Quilon limestone bed known through the researches of General W. Cullen is exposed at a place called Padappakara, 7 miles N.E. of Quilon, Travancore. During the field season 1926-27, the writer made a rich collection of fossils from Padappakara. The fossils consist of foraminifera, corals, echinoids and molluscs. Of these the representatives of the last-named are most abundant. The fauna shows affinities with those of the Gaj and Karikal beds of India, while several species are identical with those of the Miocene and Pliocene beds of the Dutch East Indies. The study of the molluscs shows that the Quilon bed fauna, in spite of its distinct admixture of Pliocene types, has essentially a Miocene character. The absence of any typical Oligocene species, and the presence of several Karikal forms, suggest the upper limit of the Gaj or Burdigalian to be the probable age of the Quilon bed.

18. Gasteropods from the Quilon limestone.

CHARLES S. PICHAMUTHU and C. PRASANNAKUMAR, Bangalore.

In a previous communication to this section of the Congress, the authors reported the re-discovery of the Quilon limestone *in situ* and also

described a few fossils collected from the area. The present paper embodies a description of a number of gasteropods from these limestones, which form the majority of the fossils. Their identification further confirms the view that the Quilon limestone represents a mixture of the Burmese and Sind facies.

COAL.

19. Action of certain solvents on Indian coal.

N. N. CHATTERJEE, Calcutta.

The present paper embodies the results of the study of the action of pyridine and chloroform on some of the Gondwana coals. The specimens include (i) Giridih coal obtained from Ramnadih Colliery, Giridih, (ii) Dishergarh coal from Aldih Colliery, Raniganj coalfield, (iii) Poniat coal from S.E. Baraboni Colliery, Raniganj coalfield, (iv) Ratibaty coal from Ratibaty Colliery, Raniganj coalfield, and (v) Ghusick coal from Ghusick Colliery, Raniganj coalfield. The alpha, beta, and gamma compounds have been determined quantitatively and their relationships with the caking and swelling properties have been discussed.

20. A short note on some Indian fusains.

N. N. CHATTERJEE, Calcutta.

In the paper the author has described the results of the physical and chemical study of fusains collected from several coal-seams of different geological ages. The specimens under discussion were obtained from (i) Talchir coal, Villier's Talchir Colliery, Orissa (Talchir stage), (ii) No. 14 seam coal, Ekra Colliery, Jharis coalfield (Barakar stage), (iii) Jilbari coal, Rajmahal hills (Barakar stage), (iv) Bora Dhemu seam, Lachipur Colliery, Raniganj coalfield (Raniganj stage), and (v) from Ara coal, Bhaganwallah coalfield, Salt Range (Laki stage, Lower Eocene). The results of a detailed chemical study in the shape of proximate and ultimate analyses of the specimens have been given in the paper. After the treatment of maceration by the Schulze solution for several days the fusain specimens were studied under the microscope, which revealed the presence of several rows of well-preserved bordered pits of different shapes in all specimens.

21. Studies in the coal problem by x-ray diffraction methods.

C. MAHADEVAN, Lingsugur.

A brief description of the technique for the study of the coal-problem by x-ray diffraction methods is given. The fundamental difference, as revealed by x-ray studies, in the nature of vitrain, durain, and fusain is brought out. Vitrain patterns are due to particles of colloidal dimensions: the durain pattern is found to be made up by superposing 'ash' and graphitic carbon spacings on the vitrain pattern. Fusain gives halos ascribable to ash and free carbon; localised spots of intensity indicate the persistence of fibre-structure. From a study of the x-ray scattering index in relation to the 'proximate analysis', a correspondence of the scattering index and the sum of 'moisture content' and 'volatile matter' rather than of either of them individually, is observed. This points to a close association of these ingredients. Of the products of breaking up coals into their so-called alpha, beta, and gamma compounds, the alpha and beta compounds are seen to give patterns nearly identical. The gamma compound pattern is quite distinct and shows similarity of structure to the x-ray pattern for resins. The x-ray patterns for the tertiary coals are seen to differ slightly but distinctly from those for the permo-carboniferous coals in spite of very similar 'proximate analyses'. The significance of this result is discussed in detail.

Section of Medical and Veterinary Research.

President.:—LT.-COL. A. D. STEWART, M.B., F.R.C.S.E.,
D.P.H., D.T.M. & H., I.M.S.

Presidential Address.

SOME REFLECTIONS ON MEDICAL SCIENCE AND PUBLIC HEALTH.

GENTLEMEN,

Your choice of President of the Medical and Veterinary Section of the Indian Science Congress this year I interpret as a very genuine appreciation of public health and preventive medicine as a branch of science. I cannot claim any great achievement in the realms of pure research; the greater part of my service has been devoted to practical hygiene and to teaching sanitary science. In choosing a subject for this address, it is natural that I should deal with matters in which I have been particularly interested. Public health and sanitary science, however, cover such a variety of matters that I have thought it better to give some general reflections on medical science and particularly public health work, rather than on any set subject.

In what follows I have given some of the qualities of mind, outlook, and belief which I think should inspire the medical man and especially the hygienist. It is a high standard but one not unworthy of our calling.

I would here deprecate the division of the science and art of medicine into categories like curative and preventive medicine. Such distinctions have now become artificial and detract from the unity of our science. When we speak of medicine therefore, we mean the science and art of medicine in all its aspects.

The science and art of medicine has three sides: curative medicine, preventive medicine, and thirdly constructive or conservative medicine, which we term hygiene. Some apply themselves mostly either to curative medicine or to preventive medicine, but real constructive medicine or real hygiene is the business of both sets of workers. If we consider the present position in England, we find that preventive medicine is becoming more and more a function of the general practitioner, while health officers are becoming more and more curative in their duties. At present curative medicine must hold the first place, but the ultimate aim is prevention of disease. As Sir George Newman says, 'It is not the event of death which we can escape but the incidence of avoidable invalidity and premature death. It is the enlargement of life and the increase of human capacity, physical and mental, which we seek to ensure'.

I would like to consider shortly with you to-day the place of scientific medicine in human life, and to consider also some qualities and attributes which, as scientists and medical men, we should have and cultivate.

Medicine was first born of the reaction of the primitive human mind to certain forces and phenomena of nature. It was closely fused in the beginning with religious feelings. This conjunction was for good, in that it recognised the psychological elements in man. It brought man at once in touch with the mysterious; and the mysterious is still the most beautiful thing we can experience, and continues to be the source of all art and science. Mostly, however, and more especially later in the middle ages of Europe, the conjunction with religion and superstition acted as a hindrance; the sanctity of doctrines and dogmas embracing physical phenomena stifled independent speculation, investigation, and experiment, which we know to be the very soul of science. Later, medicine in common with other sciences broke the bounds of doctrine and dogma; experiment and observation replaced philosophical speculation, and with the appreciation of the relationship of structure to function culminating in Harvey's discovery of the circulation of the blood, commenced that wonderful history of experiment, investigation, observation, and discovery with which you are familiar—the names of Leeuwenhoek, Jenner, Pasteur, Koch, Manson, Ross, and Ehrlich are some of the landmarks on a wonderful road along which we still travel. But in this something was wanting—the human note, the closer application of medical knowledge and science for the benefit of mankind in general. It needed the spirit of sympathy, of humanitarianism, to bring medical science into close touch with the every day life of the masses of the human race, to clothe the bones of science with life. We owe the beginning of this reunion of real religion and medical science mostly to the sympathetic labours of Sir Edwin Chadwick in 1840 on behalf of the working classes in England, and about the same time to the profoundly religious nature and preaching of John Wesley. (Of this reunion was born modern public health and preventive medicine; and the spirit that connected Harvey the experimentalist, Chadwick the legislator, and Wesley the humanitarian is that which inspires us still in our work for mankind's advancement. The preventive medicine initiated by Chadwick in 1840 and placed on a sure basis by Simon in 1875 had for its main object the improvement of man's environment. Since then the boundaries of medical science have been tremendously widened. Health is recognised to be something more than reaction of body to surroundings or the mere absence of disease. Man is a personality and an entity, a combination of body, mind, and spirit. These are not really divisible parts of men, however, but merely the results of analysis, it is the indivisible combination that

makes up the man. The conceptions of health now envisage the full development of these powers, physical, mental, and spiritual, of which man is possessed. By spiritual we mean here that part of our mind and nature which deals peculiarly with the highest feelings and emotions, with the enjoyment and appreciation of æsthetic, moral, and ethical values. We may say that we have now three aspects of public health—curative, preventive, and perfective—appertaining to body, mind, and spirit. It may be that matter, life, and mind are but different stages or levels of the same activity. Matter is the organisation, life the organism, and mind the organiser. The quantum theory has made us familiar with the idea of widely varying states and conditions arising from different quantal distributions of the same fundamental quota of energy. The development of our modern conception of public health is therefore logical—care of the body, the mind, and the spirit. We have in the past concentrated on the body; at the present day we realise more and more the importance of studying the mind. It is probably true that we cannot have a healthy body without a healthy mind. In the last 20 years we have made considerable progress in psychological study. Without pretending to particular knowledge, I think Adler has struck the most helpful note in the development of this side. Man, he says, has three problems set him by the circumstances and conditions of life on this earth—occupational, social, and sexual; how to find an occupation that will enable us to survive under the limitations set by the nature of the earth; how to find a position amongst our fellows that we may co-operate and share the benefits of co-operation; how to accommodate ourselves to the fact that we live in two sexes and that the continuance and furtherance of mankind depends upon our love-life. Readers of Bernard Shaw will remember how in his ‘*Back to Methuselah*’ he pictures a human race of great longevity and high (Shavian) intellect, in which the greater part of the period of tutelage up to 20 years, say, is compressed and spent in the egg. Actually the facts seem to be the very opposite. The human race is distinguished by its long period of tutelage and teachability after birth, and in the higher races this period is lengthened in comparison with the most primitive. As man progresses in intellectual ability it is probable that the period of tutelage will also be lengthened. Logically the period during which man should be capable of using his fully developed powers to the fullest advantage should also be prolonged. Hygiene and other euthenic measures have prolonged the average length of life in many countries, but too much importance has perhaps been attached to mere length of years. Expectation of life has meant in too great a degree expectation of bodily life. It must include lengthening of the ‘expectation of mental powers’ as well; otherwise, the gain will be illusory.

The part that medicine along with other sciences will play in the care and development of the spirit is for the future, but it will be more and more closely concerned with man in the development of his higher qualities and aspirations. To quote General Smuts, 'It is here that science ranks with art and religion. In its pursuit of truth, in its vision of order and beauty, it partakes of the quality of both. More and more science is beginning to make a profound æsthetic and religious appeal to thinking people'.

Over 2,500 years ago a Greek poet wrote :—

'Who'er can know
As the long days go
That to live is happy
Hath found his heaven.'

The Greeks, like the Hindus, emphasised certain aspects and attributes of nature, clarifying their thoughts and ideas by the conception of a presiding deity, who in the minds of the common people gradually became anthropomorphosed and an object more of fear and propitiation than a guiding principle. Certain cults in philosophy were thus engendered, each appealing and ministering to one of the many sides of human nature and human feeling, none of them true or complete in itself, but each true and satisfying within its own limits and each part of the larger unknown completeness. The words I have quoted are from a play showing the effect of 'orphyic' philosophy on the human mind. This cult insisted on and emphasised the essential and inherent beauty and sacredness of all life in nature. It is perhaps essentially a philosophy of the present, that here and now is happiness, that our existence in this world is the only thing we shall ever know, and even if it is all that we as individual creatures shall ever know, it should in itself alone be a sufficiency. It is good to be a part of life. Life only knows that it is living; it can never know that it is dead. Mortality of human mind and body in this outlook need not be regarded as any impediment to appreciation of the highest beauty in nature.

As Mimnermus said :—

'All beauteous things for which we live
By laws of time and space decay
But oh, the very reason why
I clasp them, is because they die.'

I cannot quite fully understand those who say that they can see no meaning in human life if it is mortal, if this life after death is not to be followed by an eternal hereafter. This seems a policy of despair and disappointment, a confession of lack of appreciation of the wonders of nature revealed daily to our senses and to our higher faculties.

Dissatisfaction with existence is the result of individual or

collective disappointment—a disappointment to which disease has in the past been largely the cause. National fatalism has been bred of epidemic disease. When mankind has banished or controlled disease and lives the normal span of biological existence, the individual should no longer look on death as a spoil sport but as a natural phenomenon. The desire for immortality will not be so insistent. It is a mistake to regard death itself as an evil. In the fullness of years, it is as natural an event as birth. Goethe wrote very truly, 'The spectacle of nature is always new for she is always renewing the spectators. Life is her most exquisite invention, and death her expert contrivance to get plenty of life'. The only real objection is to premature death, so distressingly common.

These ideas have attracted me for many years—that in mortal human life and existence, physical and mental, we have now nature's highest achievement, that, so far as we can see, it is nature's purpose that human life has, or should have within itself, the possibilities of complete satisfaction and happiness; that the preservation of human life, the protection and betterment of the human germ plasm, the mitigation and ultimate removal of the hindrances that beset the path or what we take to be the path of man's biological development and fulfilment, must be fundamentally correct objects of work in life, which should bring satisfaction and inspiration to the worker and benefit to his fellowmen. These aims are in large measure those of preventive medicine, and it is to those who are devoting their lives and energies to this work that I would speak with hope and encouragement. The care and preservation and improvement of human life form one of the highest ideals of work.

The thinking man at some period of his life puts to himself or has thrust on him questionings of the purpose of life, and on his own answer to himself depends his outlook on life, his career, the ordering of his actions, and his life and his relations to his fellowmen, and his bequest to posterity. There are many answers; wealth, power, happiness, peace, security, service, the avoidance of the disturbing and the distressing; and the resultant of these in the intellectual and thinking portion of a nation determine its character and its progress.

In common with many, my own conviction is that in the quest and appreciation of truth and beauty in their largest sense and meaning, lie the best answer to life's purpose, the one that gives the greatest satisfaction. Einstein says, 'To ponder interminably over the reason for one's own existence or the meaning of life in general seems from an objective point of view to be mere folly; and yet every one has ideals by which he guides his aspirations and judgement. The ideals which have always shone before me and filled me with the joy of living are goodness, beauty, and truth'.

Religion and philosophy we would expect to give us helpful and definite answers to our important questionings. Formal religion however by its insistence on human immortality and a 'soul' entity and on formality of ritual and dogma has failed to satisfy the needs of modern thinking man, while philosophy has guarded itself round with too many abstractions to come into every-day life. For the pursuit of truth we look to science, but it is the poet who helps us most in our appreciation and search of the beautiful. It is not surprising therefore that our profession of medicine has enriched the world in art, sculpture, and poetry, and two of them, John Keats and Robert Bridges, have given us perhaps the most notable contributions in the English language, exemplifying the eternal principle of truth and beauty in life. Keats, the consumptive medical student who died at 26, should be one of the most valuable possessions of the doctor. In spite of the shortness, the sadness, and the tragedy of his life, Keats was able to proclaim that beauty at any rate is real and lasting and that a belief in beauty is the one thing needful in life. 'A thing of beauty is a joy for ever' is an expression that has almost passed into our every-day life. He held that beauty was the strength which always conquered. He was no sentimentalist—no one ever looked fate straighter in the face than Keats.

.... 'For to bear all naked truths,
And to envisage circumstance all calm,
That is the top of sovereignty.'

'Beauty is truth, truth beauty' he wrote and in the essentially mutual identity of the two, lies the unity of science and art, the bridge which joins and unifies intellect and emotion, mind and spirit.

Bridges was a qualified doctor who lived a full life, and at the age of 86 wrote 'The Testament of Beauty'. In this he recounts the conclusions of a lifetime of industry and creation. Man's happiness, he tells us, is his living response to the wealth of nature. Beauty is the prime motive of all his excellence.

Life seems so full of contrasts and antagonistic elements. With nature so inexhaustible of beauty, why is there so much of ugliness; with so much that is noble and fine in civilisation, why is there still so much misery, want, disease, and vice?

We know now that what we call matter is a state of harmony between two essentially different but mutually attractive states—the proton and the electron. The study of the atom shows us that the essence of ultimate structure in nature is the existence of opposites—opposites of like and unlike, of repulsion and attraction which acting together produce equilibrium, create cosmos out of chaos, and harmony out of disorder in obedience to law. In life and civilisation we have similarly states, impulses, motives which though essentially of the same

class are nevertheless of the opposite sign as we might say. We have for instance on the one hand the instinct of self-preservation in the individual, a complete selfishness in many ways ; and on the other, love, self-abnegation, and sacrifice ; in civilised life we still have the fierce competition for existence which leads to intense nationalism, jealousies, tariffs, and wars, and on the other hand, there is a growing feeling of the unity of the human race. Nature shows how matter and life itself are harmonious adjustments of opposite entities ; in the study of constitution and behaviour of the atom there is probably much we can learn of application to the larger aspects of life, individual, social, political, and international. Bridges tells us :—

‘ Love from whom the world begun
Hath the secret of the sun
Love can tell and love alone
Whence the million stars were strewn
Why each atom knows its own
How in spite of woe and death
Gay is life and sweet is breath.’

Symbiosis and parasitism are two natural processes which have immense significance for the public health worker. They have been confused in the past but are really definitely different conceptions. By symbiosis we mean the interdependence of all forms of organic life ; by parasitism is meant the absolute dependence of one species on another. In symbiosis we have the basis of mutual assistance and development, and evolutionary progress. It leads to mutual aid and has within it the elements of ethical qualities of sociability and communal life, which lead on to the higher ethical and intellectual developments of man, to sympathy, fidelity, and courage. True symbiosis is beautiful ; one has but to instance the diversity of flowers as an example. In parasitism on the other hand we see a degrading influence and a danger of injury, disease, and possible death to the host. There is degeneration and decay in structure and form of the parasite instead of progress. It is a departure from healthy competitive evolution which demands from every organism effort, work, self-dependence, and mutual exchange of service.

Parasitism is sometimes defended by biologists as being an integral part of nature, and one often hears of public health work being considered wrong because it is said to be biologically opposed to nature and an interference with some of her methods. Parasitism is obviously immoral and a lapse on the part of some of nature's products from her higher and better methods. Parasitism is associated with all that is wrong and unhygienic in conduct, both for the individual and society. Immorality cannot seriously be defended as a legitimate expression of natural instincts. Parasitism is one of the chief, if not the chief obstacle in man's onward progress, and the reduction and final

obliteration of human parasites in India will be for some time the main tasks of the public health worker. Tolerance of parasitism by a community or by biologists is an acquiescence in a policy of ignorance and dangerous degradation, if not actually an encouragement of immorality in nature.

At the same time one cannot deny that these degenerated types are just as successful products of adaptation and evolution as are what we call the higher types. In fact evolution has tended more often in the direction of what we call degeneration than in upward progress. If, as I think we must, accept mind as represented in the human being, as essentially a product of evolution, we see how it may be possible for man to control his own evolution to some extent. In this he is unique. What form of control this will or may take, it is impossible now to say for it would appear unlikely that mind has played any important part in guiding evolution up to the present. Eugenics and population control in a wide sense suggest themselves but as Haldane points out we have been accumulating the knowledge necessary for the guidance of our evolution only for a single generation. Modern studies of heredity and genetics have revealed the extraordinary part played by the 'genes' which make up the structure of the chromosomes of the reproductive male and female cells. Chance mutations in the 'genes' produce changes in inheritable characters. Such changes when useful become permanent by natural selection. Biologists have now succeeded in producing changes in inheritable characters by physical and chemical means. The most remarkable experiments in altering the character of the 'genes' in the reproductive chromosomes are those of Harrison and Muller. The former by feeding ordinary light-coloured moths with chemicals was able to alter the pigment gene so that a true breed of black moth was obtained. Muller by X-rays and radium emanations changed fundamentally the 'genes' of the fruit fly in various ways, so that inheritable and permanent mutations were obtained. The suggestions of such experiments are far reaching. The power to change characteristics permanently is apparently a fact, but the changes cannot at present be foreseen or chosen. When man discovers how to change his characteristics in a desirable direction, he will become a master of evolution and produce human beings with finer minds and bodies who will be able to accelerate these first advances towards the human control of evolutionary destiny. Such control, if it is ever possible, is for the very distant future. At present, such ideas are mere speculations, and for many years to come it would appear that the evolutionary possibilities of man will depend on the same factors as for other species, namely, the plasticity of his germ-plasm and environmental pressure; in other words on chance recombinations and new mutations of the genes of the reproductive chromosomes, and

on a modified natural selection. In the meantime, the abolition of parasitism is one at any rate of our immediate tasks.

The instinct and desire for truth and beauty is no sentimental idea which lies only in the domain of artists and poets. It is true that the poet and the artist can best interpret beauty and show it to the ordinary man, but it is really the dominant note in all our lives. The child instinctively seeks it, it fills completely the vision of the adolescent, it dominates the selection of the mate, and guides the parent in the teaching of his children, it is the surest rock of satisfaction and contentment to the middle-aged and the old. Its seeking and its attainment give us true 'culture', give life a meaning, an object, a sense of achievement and satisfaction. Without it and without the sense of its ultimate reality and importance, many human lives are dull, meaningless, and materialistic, and many human beings disappointed and discontented. As one of our leading psychologists says: 'This search for beauty is not a meaningless search. Our æsthetic emotions are always based on a feeling for health and for the improvement of mankind. All our functions, all our abilities, are formed in this direction. We cannot escape it. We know as beautiful those things which look towards eternity, those things which are for the benefit of mankind and for the future of mankind, the symbols of the way in which we wish our children to develop. This is the beauty which is always drawing us.'

Our profession has very great advantages denied to most others—it leads us to the study of nature and man. The study of nature takes us straight to the spring of all knowledge and life; the study of man leads us to consider nature's highest achievement, a study to which we are devoting the best part of our lives. We should look at nature, not as something that provides us with a little chemistry and botany and physics but as the author of our universe, our earth, our race, and our lives. We should regard man not so much as an individual but as an integral part of nature, an interpretation of her highest motive, as a link in a chain of supreme design. Everything in nature will thus become

..... 'Symbols divine
And manifestations of that beauteous life
Diffused unseen throughout eternal space.'

The capacity and desire for the study of nature and man are themselves the reward of thoughtful life—we feel more clearly our relationship to life and nature, for the mystery of man is probably the mystery of nature.

Wordsworth's lines are familiar but can bear repetition:—

A presence that disturbs me with the joy
Of elevated thoughts, a sense sublime
Of something far more deeply interfused
Whose dwelling is the light of setting suns
And the round ocean and the living air
And the blue sky, and in the mind of man.'

.....' Nature never did betray—
The heart that loved her; 'tis her privilege
Through all the years of this our life, to lead
From joy to joy, for she can so inform
The mind that is within us, so impress
With greatness and with beauty, and so feed
With lofty thoughts, that neither evil tongues
Rash judgements, nor the sneers of selfish men
Nor greetings where no kindness is, nor all
The dreary intercourse of daily life,
Shall e'er prevail against us, or disturb
Our cheerful faith, that all which we behold
Is full of blessings.'

Planck, the celebrated physicist, considers that the study of nature fosters the two noblest impulses of the human mind—enthusiasm and reverence.

Our instinct for truth and beauty sends us to nature, and one of our strongest responses to nature is to make us listen to the 'still sad music of humanity', to awake our sense of pity with human aspirations, human suffering, and human needs. Pity is one of the strongest forces behind public health work and preventive medicine, and without it the hygienist and his work will be dull and mechanical. Pity should not stop at sympathetic contemplation, but be translated into vigorous action. In the hygienist the spirit of pity for mankind must be exalted into a moving principle. It is the mainspring of public health energy, and the well of our enthusiasm. It is the force that battles against the strong, against conventional sanctions and accepted gods, against the tyrannies of custom and prejudice. It was the driving force within the new humanitarianism of the 19th century, the force that in the hands of Wesley and Chadwick broke the selfishness and the indifference of the educated classes of England in the early days of the 19th century. Pity was thus the corner-stone of man's collective health, the structure laid so securely by these two pioneers. It has however the defects of its qualities. 'Pity is of its nature combative, it may outrun discretion and reason, and have an unreasoning contempt for consequences, and counting of costs. It may engender a spirit of recklessness, impatience of opposition, and even fanaticism and ruthlessness.' The hygienist must keep the golden mean if he can, but better sometimes a little recklessness than a placid acquiescence in opposing circumstances.

Of the very essence of pity are bred unselfishness and sacrifice, and in the hygienist these are essential qualities.

Without them he will be a disappointed man, his work will lose sanctity and grace, become mechanical, and often ill done or scamped. From them however comes the satisfaction of good work well and faithfully performed in obscure places; for the material rewards of public health work are small, and reputation and fame come to few.

The life of a medical man, general practitioner or hygienist is essentially one of curiosity. We spend our days finding out things and passing judgement on them, and translating our reasonings into actions, ordinary though the latter may be. In some the instinct of curiosity is highly developed and the search for truth becomes a passion and a purpose. We may be all research workers in a sense but it is only very few of us who have the flair and aptitude for original work. The real research worker is one of the most valuable assets of the medical community and should be encouraged in every way.

Research is not a mere matter of knowledge, nor necessarily of industry, and its results cannot be bought. It cannot be produced by any human machinery however industrious and deserving. It is like poetry; many may write rhymes but few have the real gift of poetical feeling and expression. Shelley said, 'A man cannot say "I will compose poetry"'. The greatest poet even cannot say it for the mind in creation is as a fading coal, which some invisible force like an inconstant wind, awakens to transitory brightness'. So with research—it needs the natural urge and aptitude, it needs the long apprenticeship in technique and art, untiring industry, the highest self-criticism, but above all, it needs the passion for beauty, the living coal which can be made to glow and produce the golden ore. 'Some have digged deep, yet glanced by the Royal Vein, and a man may come into the pericardium but not the heart of truth.' How many of us who undertake research have the necessary qualities, the divine afflatus? Very few we must honestly admit and perhaps there are too many of us who dabble at it; it might be better if we left the real work to the favoured few, but the dominant instinct of creation is so strong in us that we cannot deny ourselves the joy of producing even a little thing of our very own—'a poor thing but mine own'. The joy of creation is akin to that of the poet. Bridges wrote:—

'I love all beauteous things
I seek and adore them
God hath no better praise
And man in his hasty days
Is honoured for them.
I too will something make
And joy in the making
Altho' to-morrow it seem
Like the empty words of a dream
Remembered on waking.'

This is the true spirit of the research worker.

Another quality the public health worker needs, and needs always is courage ; courage that is born of belief and faith in one's work, of a life spent in the study of nature and in the quest of truth and beauty. We need it always for there is sometimes a sense of discouragement if not of actual disapproval in the atmosphere of our work. It is strange that this should be so but it is a factor to be definitely reckoned on in public health work. Let me remind you again that in the development of public health there have been two distinct ideas. Earlier pioneers like Chadwick and Simon placed the improvement of man's environment as the first essential to his health—and they were then right ; but further knowledge proved it was not the only essential. Bacteriology showed that environment though very important in its influence on bodily and mental development, was only the vehicle of disease ; it passed on microbic disease from man to man ; man was in most instances the host and reservoir of his own diseases. The study of man was the next step. Ignorance, bad habits in old and young, faulty nutrition, etc., could engender disease and ill-health in the best of environments. Education, guidance, and more co-operation between the public and the medical profession are some of the modern trends of public health. These clearly demand something from the ordinary human individual—things which he cannot buy and which cannot be gifted to him. Thus the indifference and sometimes active opposition of the individual adds to the task of the modern hygienist. There is a difference of opinion at present as to how far it is justifiable in these matters to interfere with the liberty of the individual. We can point to instances where compulsory vaccination banished smallpox, but there is the example of the U.S.A. and prohibition to show us that public morality by compulsion in one direction may lead to definite dangers in another. To take the case of India—vaccination is compulsory only in about 7% of the population ; but there is considerable evidence to show that vaccination is as well carried out in those areas where it is voluntary as where it is compulsory ; and smallpox has since 1880 been reduced in mortality from 2·12 per 1,000 to about ·16 per 1,000 all over India. There is a growing feeling at present that in public health policy too much compulsion is undesirable and should be kept rather for times of emergency and extraordinary danger. Indifference, ignorance, and conservatism on the part of the individual are definite handicaps to the health worker ; so is the idea that health is the affair of the sanitarian only and not the personal business of the community.

There is another line of criticism which appears particularly in times of stress. I refer to what is familiarly known as the 'population problem'. It is stated that in many countries and in India in particular the population has increased and is still increasing at a rate beyond its means of adequate sustenance.

Consequently and inevitably, economic stress, unemployment, malnutrition, and disease, if not worse things must ensue. Unfortunately discussions on this problem have very seldom been free from religious bias, from prejudice and sentiment, and from personal, professional, and class interest. Distinguished scientists, astronomers, and clergymen, and in particular biologists have too often used the prestige of their profession and their own personal distinction to weight their arguments. Granted the truth of these, the remedies suggested have often been hasty, superficial, and class-selfish. Some would lightly welcome disasters like floods and widespread epidemics amongst the general masses ; but these need not be taken too literally. Limitations of public health work, especially child welfare work, and the wide adoption of methods of birth control are common and serious suggestions that have been made. The subject is so important that I think a free and honest discussion on the following lines would help greatly :—

(1) What evidence is there that numbers alone are the cause of general economic stress. Is it possible to determine when sufficiency of population passes into over-population ? We might bear in mind for instance that in England human life has now been rendered increasingly tolerable to a population rising to 40 millions in an island where a century ago 14 millions had found it hard to earn a livelihood.

(2) How far have methods of population restriction alone been the cause of population adjustments ?

(3) Is it desirable that the State give facilities for instruction to the general population in methods of birth control (a) for purely medical reasons in special cases, (b) for economic reasons generally ? If desirable, are these feasible ?

(4) What would be the effect of attempts at such a movement as the latter on the rural masses of India ?

On many of these I have an open mind, but when I consider what humanitarianism and science working together have done for human welfare, I cannot believe that to discourage or curtail medical and public health work at any point—antenatal, natal, in infancy, in childhood, or in adult life can in any way be right.

I may be permitted to make one or two general observations on the subject.

Life of all sorts has been and always will be competitive. The population problem in some form or other will always be with mankind. Methods of prudence come with education, with a rise in the standard of living and a heightened sense of responsibility, and there is a considerable amount of evidence that such methods have now begun to be used extensively in the middle classes of India. Those who strongly advocate the wide adoption of such measures are probably activated by a sense of apprehension of personal or class calamity owing to increasing numbers of the so-called lower classes or races, and by a desire for personal,

class, and race security. This apprehension and this desire are psychological phenomena much commoner in the educated middle-aged adult than in youth or in the more elementary human masses. The desire for security is a manifestation of the instinct of self-preservation ; it is not however an attribute of youth but of middle age, and may be a danger and a hindrance to real progress of the race and detract from the zest of life. Is our present civilisation getting middle-aged, and are its communities seeking for security in every possible way ?

After all, the things desirable for happiness in the ordinary man are simple—food, shelter, health, love, and work. ‘Courage, hazard, and hardship and sacrifice can give a quality to human happiness undreamed of by those who sit secure in Zion.’ Those who put too great a value on security may have to make way for those who do not. The old Titan gods were displaced by a younger race of gods more adventurous than they :—

‘So on our heels a fresh perfection treads
A power more strong in beauty, born of us
And fated to excel us, as we pass
In glory that old darkness.’

We should remember that our stability is but balance, and conduct lies in masterful administration of the unforeseen.

I have indicated in some way what I consider should be the attitude of the medical man and specially the practitioner of preventive medicine towards his science and his work. A constant desire for truth ; an appreciation of the beautiful, and of the essential reality and unity of these two ; a spirit of sympathy and pity for the human race ; continuous assiduity in the alleviation and prevention of disease ; a belief in the possibility of upward progress of mankind through evolution controlled by intelligence, and in the application of the ideals of preventive and constructive medicine in the development of man’s higher attributes ; a spirit of conviction and courage in the face of difficulties.

In conclusion, gentlemen, I would remind you that we meet here with the intention of mutual benefit, of giving the results of original work, of original ideas, of presenting problems, of asking for and helping in giving indications for progress.

‘What cheers us most is still the cry
Of those who look for larger sky
And find with every cloud withdrawn
Fresh promise of an ampler dawn.’

Only the best and most talented and industrious of us can push aside the clouds, but all of us can keep on looking and learning. Medical life is surely therefore one of the best and most satisfying and interesting. One of the great attractions of science is that it is limitless and will probably always be somewhat of a mystery.

‘Remember that in that inner world to which great literature, science, and art belong, a man may go on all his life learning to see, but he can never see all that is there, he can only hope to see deeper and deeper, more and more, and as he sees, to understand and to love.’ In this spirit, gentlemen, I commend to you the science and art of our profession and specially the meetings of our own section of Medical and Veterinary Research.

Section of Medical and Veterinary Research.

Abstracts.

BACTERIOPHAGE AND FILTERABLE VIRUSES.

1. Epiphytotic diseases of plants as illustrated by bacteriophages lysing the vibrio of cholera.

Lt.-COL. H. W. ACTON, Calcutta.

Certain virus diseases of an ultra microscopic nature have been known to attack the higher plants and produce disease. In this paper an attempt will be made to show that the bacteriophages are really virus diseases of simple thallophyte plants. The main discussion will be on the size of the phage which is roughly about 5 to 25 μ , whilst the bacteria varies from 1.5 to 5 μ and about .5 μ in breadth. These bacteriophages are more or less specific for the particular bacteria, but can be acclimatised to grow on other bacteria or closely allied species. The phage is most potent in its action on the young cultures and becomes less powerful with older cultures. During the growth and multiplication of the phage on these bacteria lysis occurs, and solution seems to be complete for the first few hours. Later on secondary growth appears and these now are resistant to the action of the particular phage. In this way a number of phages have been discovered which vary in the shape and size of the lysed plaque, the size of the phage and their resistance to heat. Their virulence can be altered by subculture, usually in the test tube the phage becomes weaker with subculturing. In no case has there been discovered a phage of these bacteria which will kill with certainty every individual of the population.

The phage therefore appears to be a virus disease of these small thallophyte plants, and their action is to destroy the more sensitive young bacteria with the result that a race develops (secondary cultures) which can resist the attack of the virus. The obvious conclusion in the manufacture of phage is to get a sufficiently large number of races from their natural sources such as sewage, etc. and not from artificial cultures made in the laboratory.

2. Bacteriophage in the treatment and prevention of cholera.

J. MORISON, E. M. RICE, and B. K. PAL CHOUDHURI.

An epidemic of cholera comprising about 600 cases and 238 deaths broke out in Sibsagar along the banks of the Dikhu river during July, August, and September of this year. Cholera had not visited this area since 1917. The origin of the epidemic was a single case which brought the infection from Gauhati 200 miles away. This case gave rise to a group of four cases, with some reason considered to be 'choleraic diarrhoea', on the river bank and directly and indirectly from these cases fifty-three villages were infected. The infection by the river produced a very few cases in each of a number of villages. The subsequent spread of the epidemic in these villages followed commensural lines and contrasted with the water-borne element which affected different classes of persons indiscriminately.

Bacteriophage was used for nearly half the cases without any selection. Among those who had not the bacteriophage the mortality during the first three weeks was 62.7%. This fell to 47.5 at the height of the

epidemic and to 33·8% during the decline. Among those treated with bacteriophage the mortality at the beginning of the epidemic was 23%, at the height of the epidemic 23·9 and the close 24·8. The reduction of the mortality seen in the control cases and commonly seen in epidemics was not evident among those receiving bacteriophage.

The value of the agglutination test in determining whether recovered cases were actually cholera was demonstrated, and it is suggested that more use be made of the agglutination test in determining so-called 'choleraic diarrhoea' which in this instance was a link between the epidemic in Sibsagar and cases in Gauhati.

In Nowgong and Habiganj, two endemic centres of Assam, cholera-dysentery bacteriophage is being given as far as possible to all cases of diarrhoea, dysentery, and suspected cholera. In Nowgong this commenced in December, 1929, since when there has been no outbreak. Habiganj was used as a control area and was visited by cholera biennially. In June, 1932, the use of bacteriophage was extended to Habiganj, in preparation for the expected annual epidemic in November.

INFANTILE MORTALITY AND VITAL STATISTICS.

3. Infantile mortality in India.

LT.-COL. A. J. H. RUSSELL.

This paper deals with the incidence of infantile mortality in all India and in individual provinces for the period 1892-1930. Figures have been plotted on graphs and attention is drawn to various peaks which have occurred from time to time and to a rather surprising downward trend in the incidence of infantile mortality rates, practically over the whole of British India, since the influenza epidemic of 1918-19. The causes underlying this trend are briefly discussed, but the paper is presented rather to stimulate interest and discussion than to give a reasoned explanation of this remarkable feature.

4. 'Normal' age distribution of India.

H. P. CHAUDHURI, Calcutta.

The age distribution of the Census population in India is not a true representation for the following reasons :—

- (a) Irregularities in the Census record;
- (b) Insufficient and unsatisfactory birth and death registration; and
- (c) General misstatement and misconception of age.

'Normal' Age distribution, which is the subject matter of this paper, is stable and more representative of the real situation for the fact that it depends for its basis on a fundamental law of growth, i.e. on a Mathematical formula

$$C(a) = be^{-ra}p(a)$$

which has been found to be true.

Points raised :—

- (1) Basis of the Formula;
- (2) Deduction of the constants from the available data;
- (3) Discussion on constant rate vs. varying rate of increase;
- (4) Possible age distribution of census enumeration, 1921-1931.

MALARIOLOGY.

5. The value of the 'thick film' method in the diagnosis of malaria.

A. C. UKIL and S. C. CHOWDHURY, Calcutta.

Out of a total of 170 samples of blood examined, malarial parasites were found in 43 cases. The 'thick film' showed malarial parasites in 60% of the cases, where the 'thin film' search was negative. The degree of concentration of parasites in the 'thick film' was found to be 9-25 times or an average of 15 times of that present in 'thin film'. The positive cases showed an average of 8% of large mononuclears on differential count. L.D. bodies were found only in one case in the 'thick' film.

6. Malaria and Anopheline fauna in Patna.

B. C. BASU, Calcutta.

In October, 1930, while on leave, a study of the Anopheline fauna and malaria of Patna, the capital of Bihar and Orissa, was conducted. Species of Anopheline mosquitoes found breeding were as follows:—

- A. subpictus*, Grassi.
- A. vagus*, Donitz.
- A. barbirostris*, Van der Wulp.
- A. hyrcanus* var *nigerrimus*, Giles.
- A. fuliginosus*, Giles.
- A. culicifacies*, Giles.

A. subpictus was the predominating species. *A. culicifacies* and *A. fuliginosus* seem to be the carrier-species in the area.

Special attention was paid to find out *A. stephensi*, Liston., the notorious malaria-carrier species of Indian towns; though without success (period of survey being 8 days only) it is feared if this species really exist or is once introduced in the area, it will be a difficult problem to control it as the congenial breeding places for this species are innumerable, wells being the chief source of water supply.

Regarding the species of malaria, *Plasmodium vivax* and *Plasmodium falciparum* were found—the latter being the predominating species.

The paper will contain a detailed description of the breeding places of the mosquitoes, monthly figures of malaria cases and their correlation with rainfall and general hygienic condition of the town.

7. Mass treatment of malaria in the rural areas of the United Provinces as an anti-malarial measure.

A. C. BANERJEA.

Mass treatment of malaria is an anti-malarial measure of great importance in rural areas where other measures are not commensurate with the cost. The two malarial seasons being synchronous with the sowing and reaping of the principal crops vitally affect the agricultural population and it therefore follows that if the labour population could be kept fit during these two seasons, it would mean a considerable economic gain to the villagers.

With a view therefore to relieve this situation, a scheme of mass treatment was initiated in 30 groups of villages in 6 districts in 1928 and continued till March, 1931. It consisted of free distribution of cinchona febrifuge tablets to the malaria sufferers by a literate resident villager on a small monthly remuneration. Three days' course of treatment consisting of 90 grains of cinchona per adult person and correspondingly

reduced dosage for children was prescribed but in actual practice the adults only took 60 grains in three days and the children the dosage recommended. The treatment aimed at only a clinical relief and not a parasitic cure. During the years 1928-30, 12,565 cases were treated and the rate of febrile relapse for the years 1928, 1929 and 1930 worked out to 28.8%, 18.8% and 11.2% respectively and 2.5% of the cases required more than 3 days' treatment in the first instance varying from 4 to 6 days. Cases and relapses relate to the sufferers who actually reported sick from fever.

As a result of the operation of this scheme for a period of three years, the vital statistics of these areas have improved and the spleen rate has come down from 45% to 14.2% while in the control series these figures only show minor fluctuations. The shortening of sick days from a fortnight or even several weeks to 3 to 5 days means a considerable gain to the villagers and it has been roughly assessed that this gain in the case of wage earners amounted to nearly Rs. 21,000. There has been a great demand to extend the benefits of this scheme to other villages but obviously no country or State can afford this as a wholesale measure. In view of the popularity of the scheme it has, however, been possible to introduce a sale scheme on a commission basis. This scheme, besides being cheap, is self-supporting and works automatically and needs no large investment of money for the initial purchase of the drug. Moreover it provides a source of income to the ill-paid teachers of the village schools and is therefore sufficiently attractive.

8. The serological diagnosis of Malaria.

LT.-COL. LABERNADIE, Pondicherry.

It is a known fact that the diagnosis of malaria should be based on the evidence of malarial parasites. They are easily found in acute forms or in recent infections; when the disease is becoming chronic, malarial parasites are rare in the peripheral blood, but leucocytes differential count stands for the diagnosis. Later on and specially amongst natives, the differential count is normal although the disease is not cured. Therefore the diagnosis of old malaria is often difficult.

Research workers have often thought that a blood disease as resistant as malaria must bring forth some serological changes. What changes? Some years back, Henry has shown that the serum of malarial patients after a time of infection has a tendency to flocculate in the presence of certain iron salts or more with 'melanine'. The degree of flocculation calculated precisely by a photometer is proportionate to the importance of the infection.

This reaction fills up an important gap in the diagnosis: by this, the chronic cases are easily detected.

We are therefore well equipped for the diagnosis of malaria:

acute malaria—search for malarial parasites.

chronic malaria—Henry's reaction.

This reaction is also helpful in guiding to control the treatment of malarial patients.

TUBERCULOSIS.

9. Localisation and character of pulmonary tuberculosis in India.

A. C. UKIL, Calcutta.

The localisation and character (exudative or productive) of lung tuberculosis among the cases attending the chest department of the Calcutta Medical College Hospital during the year 1931-32 have been given. The data obtained tally with the author's earlier findings on the epidemiology and pathology of the disease in India.

10. A study of tuberculosis at Pondicherry.

LT.-COL. LABERNADIE, Pondicherry.

By the modern equipment of the Colonial Hospital, the diagnosis of the disease may be rather accurately obtained—X-rays; laboratory sputum examination, and inoculation of the guinea-pig; blood examination sedimentation test, Vernes' test (a method of flocculation with resorcin as an antigen); von Pirquet's reaction, etc.

After five years' stay and observation in Pondicherry, the author can state that :—

1. Tuberculosis is relatively rare.
2. Pulmonary acute forms are exceptional.
3. Chronic fibrous forms are the rule and their evolution is generally benign.
4. Surgical forms (joints, bones, orchitis) are not uncommon. They are successfully treated with the methylic antigen of the Pasteur Institute, Paris (Negre and Boquet).
5. Against pulmonary forms, gold treatment, although prolonged a long time, has given only small results. The treatment with choline, in order to increase the cholesterol in the blood, seems far more effective.
6. Scarcity and benignity of tuberculosis at Pondicherry are no doubt due to the fact that the virus reservoir is less important than in other places. So the causes of contamination are less frequent and heavy than in big cities.

In fact, the von Pirquet's reaction gives the following figures (positive).

Up to the 6th year.	0
From 6th to 10th year	7.7%
„ 11th to 15th	„	38%
„ 16th to 30th	„	57%
„ 31st to 35th	„	70%
„ 36th to 55th	„	80%

11. How to assess the prognosis of lung tuberculosis cases in India.

A. C. UKIL, Calcutta.

It has been shown in the author's earlier papers that the tubercularisation of the population in urban and rural areas in India varies and that massive infection and defective immunisation are prominent factors in determining the march of the disease in India. In addition to other points, the skiagraph of the lungs has been found to be a very reliable index in determining prognosis and in indicating the method of treatment. The present paper, which will be illustrated with radiographs and other data, deals with the method which the author has found most useful in his own experience.

12. The use of Lipiodol in the diagnosis of certain lung conditions in India, particularly bronchiectasis, abscess and gangrene.

A. C. UKIL, Calcutta.

Diagnostic exploration by intratracheal introduction of Lipiodol was employed in 40 cases, in a series of nearly 2,000 cases attending the chest department (out-door) of the Calcutta Medical College Hospital to elucidate either the cause of unexplained hæmoptysis or bronchial dilatation or the nature of an abscess. This method has helped us in finding

out early and advanced cases of bronchiectasis which is undoubtedly much rarer here than in temperate climates. The data are given, illustrated with skiagraphs.

CONSERVANCY, WATER AND SEWAGE BACTERIOLOGY.

13. Recent developments in the disposal of towns' refuse by biochemical methods.

GILBERT J. FOWLER.

Since the publication in the *Agricultural Journal of India* for September, 1930, of a 'Review' of the research work done in India up to that date on the preparation of organic manure, considerable developments have taken place and the subject is becoming of worldwide interest.

In India the whole of the refuse and nightsoil of Mysore City is being converted into a valuable manure, many tons of which have been used by the Mysore Department of Agriculture for fertilising sugarcane in experimental areas irrigated from the Irwin Canal. Excellent results are reported. The work is being carried on by a representative Committee of which the Director of Agriculture is Chairman.

Progress in similar work has been made by the city of Bhopal, and there is stated to be a large demand for the product at a remunerative price.

Messrs. Howard and Wad have published an important volume entitled *The Waste Products of Agriculture*, describing the methods used at Indore for transforming the weeds, straw and other waste material of the farm into valuable 'compost'. A simplification of these methods has been recently announced by Messrs. Jackson and Wad, of the Institute of Plant Industry, Indore.

Experiments on a fairly large scale are being carried out by the Director of Public Health of the Government of Madras in Madras City, Ootacamund, and other centres in the Presidency.

Important researches on the biochemistry of the composting process have been for some time in progress in the Department of Biochemistry of the Indian Institute of Science, Bangalore. This Department is now working in collaboration with the Mysore Composting Committee.

In Germany a voluminous literature has grown up around the Krantz hot fermentation process employed in the production of 'Edelmist'.

A lecture describing the work in India and elsewhere was given in London on 23rd May, 1932, by R. D. Anstead (retired Director of Agriculture, Madras Presidency) to the Institution of Sanitary Engineers. This lecture with illustrations and a lengthy discussion was published in the *Journal of the Institution of Sanitary Engineers* for June, 1932, and has attracted wide attention. The lecturer stressed the demand for large quantities of organic manure to fertilise the allotment gardens which are increasing in number in England.

As a result of the lecture in England experiments are being made at certain sewage works to dewater wet activated sludge by composting it with towns' refuse.

Experience indicates that in India or wherever complete water carriage of sewage is not available a special form of activated sludge tank should be provided at comparatively small cost in which nightsoil can be diluted with sullage or with water and undergo preliminary treatment sufficient to eliminate nuisance before fermenting it with the town's refuse.

14. A comparative study of cyanide citrate pour plate medium for direct determination of colon-*aerogenes* content of water with Clemesha's method.—A preliminary report.

LT.-COL. A. D. STEWART and S. C. GHOSAL, Calcutta.

Principle involved in the use of this medium. Method of preparation and examination of water. Types of colonies—productive efficiency. Comparative results by the cyanide citrate plate method and Clemesha's method. Conclusions.

15. Incidence and viability of *B. typhosus* and *Salmonella* organisms in sewage.

LT.-COL. A. D. STEWART and S. C. GHOSAL, Calcutta.

Medium used—Wilson and Blair's bismuth sulphite medium for isolation of *B. typhosus* and Gray's lithium selective and enrichment method for isolation of *salmonella* organisms. General consideration of the two media with demonstration. Three different types of sewage examined—

(1) Septic tank effluents of different mills.

(2) Raw and final effluents of an activated sludge plant.

(3) Calcutta sewage from different places. Incidence of *B. typhosus* in different types—difficulty during monsoon. Rarity of *salmonella* organisms. Viability of different organisms in sewage. Conclusion.

16. The value of the Eijkman test in water examinations.

V. GOBINDA RAJU, Calcutta.

An investigation was carried out on the value of Eijkman's test which consists in incubating at 46°C. tubes of glucose peptone water inoculated with varying quantities of the sample of water. The results obtained in the case of waters of various kinds in Bengal do not show that the method possesses any advantage over the standard method. There is distinct evidence that a marked inhibitory effect is produced by the temperature of incubation on even undoubtedly faecal organisms. Dilute emulsions of faeces showed a much smaller number of colonies by the Eijkman method than by the standard method. No evidence was also obtained that by the Eijkman method the *aerogenes* group of organisms could be eliminated to a greater extent than by the standard bile salt lactose broth at 37°C.

17. Faecal flora of Bengal as indicators of sewage contamination of water, a preliminary study.

B. B. BRAHMACHARI and G. N. SEN, Calcutta.

Bacteriological standard of purity of water is based on Clemesha's studies of Madras faeces. We examined 25 Bengal faeces and found (a) that while some members of the colon group were common to both provinces, others were different, (b) that their relative prevalence differed, (c) that in 20 per cent. of Bengal faeces Class I bacilli were absent, and that in some faeces Class II were so distributed that with the 10 colonies of routine examination, the bacilli found in the contaminated water might be only of Class III or a Class II one with or without one or two other Class II or III bacilli, and (d) that in some faeces all the ten colonies

from polluted water might be Koser-positive. Can we, in face of this finding, pass, for drinking, surface water containing colon bacilli less than 10 c.c. even if Class I is absent, or Class III alone present, or one Class II present with one or two other bacilli of Class II or III ?

18. Viability studies on pathogenic bacteria in raw sewage, sludge, and effluent.

N. G. CHOKKANNA, Bangalore.

Samples of raw sewage, sludge, and effluent were plated on selective media for bacteria of the colon-typhoid group, the vibrio group and for *B. tuberculosis*. Growths on the last two were very poor while those on the former were fairly large. Viability of these organisms are being studied by inoculating them into samples of raw sewage, sludge or effluents and soils irrigated by them.

MISCELLANEOUS.

19. Some observations on the modern technique of the preparation of smallpox vaccine lymph.

M. A. MAJID, Calcutta.

1. Varieties of vaccine lymph—wet and dry.
2. Routine method of their preparation.
3. The technique followed in different Vaccine Institutes of India and the newer methods introduced in Bengal.
4. Regeneration of seed lymph—Nijland's and modified Nijland's methods.

20. Results of prophylactic cholera inoculation in an Orissa village.

J. L. DAS, Bihar and Orissa.

The paper describes the results of prophylactic cholera inoculation in an Orissa village with a population of 3,000. Among the inoculated the case incidence was 0.56 per cent. against 15.4 per cent. among the uninoculated. The case mortality among both the inoculated and uninoculated did not differ very much. No evidence of a negative phase following inoculation was observed. One case developed cholera in spite of two inoculations.

The points coming up for discussion are :

- (1) if the strength of vaccine could be lowered without interfering with its protective power ;
- (2) the time the immunity takes to develop after inoculation ; and
- (3) what period the immunity lasts ?

GENERAL MEDICINE, NUTRITION, BIOCHEMISTRY AND VITAMINES.

21. A rapid and fleeting review of the history of medicine.

D. N. BANERJEE and MRS. D. N. BANERJEE, Calcutta.

This is an attempt to have a glimpse into the history of medicine from the primitive man up to our own times. This will be exhibited

by means of four lantern slides each showing a chart indicating the dial of a clock, each minute of which will represent 10,000, 100, 10 and one year respectively of the world's history.

22. A peep into Palæontopathology.

D. N. BANERJEE, Calcutta.

This is an attempt to study the diseases of the ancients as recorded on the 'record of rocks'.

The source of this study is the record of the fossils throughout the world which show evidence of pathological condition. The recent attempt to examine the Egyptian mummies by means of X-Rays also affords a good field for the above study. This study includes not only the pathological conditions of the ancient human being but also of the extinct mammals, reptiles, etc.

23. The Vitamine B content of Indian rice by Spruyt's colorimetric method. Part II.

H. W. ACTON, SUDEHAMOY GHOSH, and ASHUTOSH DUTT,
Calcutta.

This paper deals with the assay of samples of rice collected and prepared under standard conditions. Samples of paddy with white and red pericarp were collected, and hulled samples of both sundried (*atap*) and parboiled rice prepared from these. Six of the samples were polished and four polished samples were washed in running water for 48 hours. The colour-index of each of these samples was estimated in duplicate by Spruyt's method as modified by us. Feeding experiments with *munia* birds were also done with some of these rice samples. The colour-index showed a regular fall with the degree of hulling and polishing. The subsequent washing caused a very big drop in the colour-index. The polishings showed a very high colour-index and the polishings from *atap* rice showed a higher value than those from parboiled ones. The polishings from rice with white pericarp showed a higher value than those from rice with red pericarp both in *atap* and in parboiled samples. The effect of polishing was very much more marked in *atap* than in parboiled rice. This was also corroborated by feeding experiments.

24. Biological assay of Vitamine A in the body oil of rohit, mirgal and dhain (Freshwater fish from Bengal).

N. C. DATTA and B. N. BANERJEE, Bangalore.

All the above-mentioned oils gave the characteristic blue colouration with antimony trichloride, the colouration being rather lighter in the case of the dhain oil than in the others. Experiments were carried out to find out how these oils responded biologically since colour test for vitamine A is not above criticism.

Experiments were carried out with albino rats. Young rats were kept on vitamine A—free diet for 4 to 5 weeks till they attained a constant weight and developed xerophthalmia. About 80 per cent. of the rats developed xerophthalmia. Then they were given a supplement of different oils in doses of 20, 50, 100 mg. per day. Another set of rats were kept on cod-liver-oil in same doses for comparison. With Rohit and Mirgal fish oils the rats responded very well. Those getting 50 mg. of these oils increased 9 grms. in weight per week and other set with 20 mgs. of oils increased 4 grms. in weight per week on an average. Hence taking an increase of 3 grms. weight per week as 1 unit of vitamine A (U.S.P.) these oils contain about 66 unit of vitamine A per grm. of oil. The rats

did not respond at all to Dhain oil. They increased in weight slightly during the first week but later they declined in weight and died.

It has been observed that for testing vitamine A value, biologically 5 weeks period is the best.

The vitamine value of the oils in terms of Lovibond blue units is in progress.

25. The thyroid gland as affected by deficiency of Vitamines A and B.

R. K. PAL, Patna.

Deficiency of vitamins A and B individually after two months' experimental feeding led to changes in the action of thyroid gland of the nature of hyper-function, in rats, the effect being much more pronounced in the deficiency of vitamine B. The growth-promoting nature of both the vitamins can be explained by diminished metabolism caused by resting phase of the thyroid glands of animals fed with vitamine containing diet.

Regarding the antitoxic nature of vitamine A, it has been proved by the Reid-Hunt reaction on mice that vitamine A feeding produces results on the thyroid gland like thyroid feeding and as such animals can resist against poison like acetone nitril by promoting complete resting phase of the thyroid gland and also increasing the number of phagocytic cells in the gland itself. Vitamine B, though it has got an action on the thyroid gland similar to vitamine A, does not increase the number of phagocytic cells in the thyroid gland and probably that is why no antitoxic property can be attributed to it.

26. The proteolytic enzyme in cucumber (*Cucumis Sativus*) N.O. Cucurbitaceæ.

R. N. CHOPRA and A. C. ROY, Calcutta.

Cucumber contains a fairly strong proteolytic enzyme which is ereptic in nature. It hydrolyses Witte's peptone with the formation of tryptophane but has no action on fibrin. The activity of this enzyme is at its optimum at a Ph range 5.5 to 6.2; a reaction more acid or alkaline tends to inhibit its activity. It hydrolyses casein solution with the formation of tryptophane and also clots milk and liquefies gelatine. The endocarp has a higher concentration of this enzyme than the mesocarp. The enzymatic activity is stronger in the mature fruits, in which the seeds have hardened, than in immature ones. HCN activates the enzyme considerably but this action does not appear to be specific as in the case of papain or bromelin, as it is activated to almost the same extent by dilute HCl or citric acid.

27. A note on the reversible oxidation-reduction of glutathione in liver.

K. C. SEN, Muktesar.

The object of this note is to discuss some aspects of the rôle of glutathione in cellular respiration. It has been recently shown by Hopkins and Elliot (*Proc. Roy. Soc., B.* 1931, 109, 58) that during the survival respiration of liver tissue there appears to be a balance—at least at the early stage—between the oxidation and reduction of glutathione and it seems that apart from the earlier thermolabile tissue residue of Hopkins and Dixon (*J. Biol. Chem.*, 1922, 54, 527), an enzymatic system is also involved in it. While the above work was going on, the present writer, at the suggestion of Sir F. Gowland Hopkins, tried to isolate this enzym-

atic system at the Cambridge laboratory. The effect of different common metabolites on the liver system was also tried in order to increase the amount of reduction of oxidised glutathione, and though glucose sometimes gave a slight positive result, thus probably giving an indication of the enzyme concerned, the work could not be completed for lack of time. With the discovery of glucose dehydrogenase later by Harrison (*Biochem. J.*, 1931, 25, 1016) it has recently been shown by Mann (*Biochem. J.*, 1932, 26, 785) that this particular system is capable of reducing the oxidised form of glutathione. The amount of reduction however seems to be small and it cannot be said how much of the *in vivo* reduction is due to this system. It appears that there may be other thermolabile systems present in the liver. An interesting fact has been observed by the present author that a part of this reduction, obtained either by anaerobic incubation of liver tissue containing some pre-formed oxidised glutathione or by aerobic incubation of liver in presence of added oxidised glutathione, is a surface reaction which can be inhibited by urethane. If it is assumed that the urethane acts on a dehydrogenase, then according to Keilin's theory, cytochrome is also involved in it. Another interesting fact is that in the reduction of oxidised glutathione by liver, intact cellular structure is not essential, but with red blood corpuscles Meldrum (*Biochem. J.*, 1932, 26, 817) finds that destruction of the cellular structure prevents the reduction. This phenomenon complicates the problem of how glutathione is kept reduced in the different organs of the body.

28. A new method of estimation of sugar in urine of advanced cases of glycosuria.

K. N. BAGCHI.

1. There is a close relation between elimination of chlorides and elimination of sugar in urine of a diabetic subject.

2. The excretion of sugar takes place at the expense of other solids, chiefly the chlorides—the higher the percentage of sugar the lower the percentage of chlorides, and they vary proportionately.

3. The percentage of sugar present in a sample of urine can be accurately determined without doing any Fehling or Benedict titration by the following method:—

(a) Determine the specific gravity of the urine at 15°C.

(b) Estimate the percentage of chlorides (as NaCl).

(c) These two data are then worked out into the following formula—

$$\frac{G - (Cl \times 10)}{4.4} = \text{Percentage of sugar.}$$

where G = Specific gravity at 15°C., only the last two figures being taken.

Cl = Percentage of chlorides as NaCl.

For example, a sample of diabetic urine with 1035 as specific gravity and 0.25% of chlorides gives

$$\frac{35 - (0.25 \times 10)}{4.4} \%$$

or 7.38% of sugar.

4. This formula is fairly accurate in estimating sugar in urine of diabetics who have not undergone any dietetic treatment and who are living on their usual Indian diet.

5. Limitations—(a) Complicated with Bright's disease.

(b) Undergoing dietetic treatment.

(c) Having excess of phosphates or urates in the urine.

29. The effect of chloroform on the cholesterol content of blood and other organs in the pigeon.

N. C. DATTA, Bangalore.

In a preliminary study (*Proceedings Indian Science Congress, 1932 Abstracts, Section of Med. and Vet. Research*), it was reported that under the action of chloroform there was slight increase in blood cholesterol. It was observed later on that by repeated administration of chloroform to pigeons for 3 to 4 hours daily there was a definite increase in blood cholesterol.

The various organs, viz. brain, liver, kidney, lungs, and heart of both the experimental and control animals were analysed for their cholesterol contents in order to find out whether the increase in blood cholesterol as was suggested by Doree and Gardner in the case of starvation, or (2) whether the excess of cholesterol has come from the brain as Bebra and Harles (*Biochem. J.*, 1914, XIX, 1) believed that ether anaesthesia due to the dissolving out of brain lipoids. It was observed by us that the cholesterol which is present in these organs is mostly in the free state and is almost constant (normal). Besides the cholesterol, the fat content of the different organs with the exception of liver was found to be quite constant. The only change observed was that the animals under chloroform declined in body weight and had lost almost all of their adipose tissue fat. It is therefore considered probable that the excess of cholesterol in the blood is due to mobilisation of reserve fat into blood rather than to any destruction of tissue.

PSYCHOLOGY, PHARMACOLOGY, AND THERAPEUTICS.

30. 'Functional' and 'organic' disease.

LT.-COL. O. A. R. BERKELEY HILL, Ranchi.

The last few years have seen developments that are of special importance for the illumination of the concepts of 'functional' and 'organic'. No clinical examination is complete unless it involves evaluation of the psychical factors in any case of illness. Likewise, no psychical valuation is adequate unless the morphology and physiology of the patient have been considered. Relation of two clinical histories to illustrate this contention.

31. Addiction to hemp drugs in India.

R. N. CHOPRA and G. S. CHOPRA, Calcutta.

The hemp drugs have been used in India from times immemorial to overcome fatigue and worry, to give courage to the warriors during the period of stress and to produce euphoria. Since the Hemp Drugs Commission of 1894 little or no work has been done to gauge the prevalence of these drug habits in India. The present enquiry into the incidence of addiction to hemp drugs and the effects produced by them was financed by the Indian Research Fund Association.

The habitual use of these drugs in British India at the present time is even more extensive than that of opium. The principal drugs consumed are 'ganja' and 'charas' which are generally smoked and rarely taken by the mouth, and 'bhang' which is always eaten. By extensive work in the field extending over many years we have calculated that there are approximately over a million persons who use 'ganja' habitually, a quarter million who use 'charas', and over half a million who drink 'bhang'. The hemp drug addicts thus form 0.19 per cent. of the total population of British India, which is a very high rate of in-

cidence. From a close study of 1,500 cases we have worked out the average dose of 'charas' and 'ganja' to be 8 to 10 grs. each daily and of 'bhang' a little more than double this quantity. A study of the distribution of these drug habits in different provinces shows that the United Provinces have the highest incidence and next in order come the Punjab, Bengal, and Sindh. In Southern India the incidence is considerably less than in Northern India.

The factors that determine the extent of addiction to hemp drugs are religious, social, geographical, and economic. These drugs are abundantly consumed in places of Hindu pilgrimage and religious centres which abound in the United Provinces. Among certain castes they are used at times of marriage or other festive occasions. The northern parts of India experience extremes of climate and a small rainfall and the poorer section of the population resort to 'bhang' and 'charas' to combat these extreme variations. 'Ganja' is consumed in those parts where the climate is more equable. The towns with markets for agricultural products such as Amritsar, Lyallpore, Amraoti, and Cawnpore, and industrial centres like Calcutta, Bombay, Cawnpore, etc. show a high incidence. These drugs, in fact, are the sedatives used by the poorer classes throughout India and are more used in the urban than in rural areas. The extensive use of hemp drugs in this country is said to be responsible for crime and insanity, but the data on which these assertions are based is insufficient.

32. Observations on the efficacy of anhydrocotarnine resorcinol hydrochloride (a derivative of narcotine) in the treatment of malaria in monkeys.

R. N. CHOPRA, B. MUKHERJEE, and H. G. M. CAMPBELL,
Calcutta.

The Opium Commission (1893) reported that opium might have an antimalarial action. Gordon (*Ind. Annals of Medical Science*, Vol. VII) showed that narcotine, one of the important subsidiary alkaloids of opium, had some value as a prophylactic in malaria. Chopra, Mukherjee, and Dikshit (*I.J.M.R.*, 1930, 18, 35) and Chopra and Knowles (*I.J.M.R.*, 1930, 18, 5) have worked out the pharmacological action of narcotine and have shown that it has no curative or prophylactic value in malaria, even in large doses. As narcotine is obtained in India in large quantities as a bye-product in the manufacture of morphine and codeine, and is at present allowed to go waste, attempts were made, at the suggestion of the Central Board of Revenue, by Ahluwalia, Kochhar, and Ray (*J. Ind. Chem. Soc.*, 1932, 9, 215) to convert narcotine into an antipyretic and antimalarial remedy. A series of compounds were accordingly prepared by oxidising narcotine to cotarnine and later condensing cotarnine with phenols like phloroglucinol, pyrogallol, and resorcinol. The pharmacological action and antimalarial efficacy of one of these compounds (2':4"-Dihydroxyphenyl hydrocotarnine) were investigated by the present authors.

The pharmacological action of this compound resembles in many respects that of narcotine. The drug is sparingly soluble in water and is fairly toxic to lower forms of life like *Paramæcium caudatum*. The blood pressure falls and the respiration is slightly stimulated in doses of 10 to 15 mg. injected intravenously. The antimalarial property has been studied by experimentally infecting *Macacus rhesus* monkeys with malaria. The incubation period in these animals varies from 8-14 days according to the severity of the infection. Blood smears were examined every day and as soon as rings and schizonts were noticed in the peripheral blood, the cotarnine compound was injected intramuscularly in doses varying from 10 to 80 mgms. In 10 monkeys experimented upon the drug has failed to produce any change in the blood picture and

has not changed the progress of the infection in any way. The rectal temperature is slightly lowered in most monkeys following the injection of the drug but the parasites multiply in the usual way and the animal dies within 3-5 days as a result of the infection. From the experimental data, it appears justifiable in concluding that the drug is of very little use as an antimalarial remedy.

33. The pharmacological action of 'Ajmaline'—an alkaloid occurring in *Rauwolfia serpentina*, N.O. *Apocyanaceæ*.

R. N. CHOPRA, J. C. GUPTA, and B. MUKHERJEE, Calcutta.

Rauwolfia serpentina is a large climbing shrub commonly found in the tropical Himalayas, Assam Hills, and in the plains in various parts of Bihar. The root has been much valued in India and the Malayan Peninsula from very ancient times as an antidote for the bites of poisonous reptiles and as a febrifuge. Recently the drug has become popular as a remedy for insomnia, hypochondria and insanity on account of its wide-spread use in the indigenous medicine in Bihar. Sen and Bose (*Ind. Med. World*, 1931, July) first reported the presence of two alkaloids with different melting points in addition to other organic and inorganic matters. Siddique and Siddique (*Jour. Ind. Chem. Soc.*, 1931, Vol. 8) carried out a detailed chemical examination and found five new alkaloids with different melting points and constitutional formulæ. The present investigation was conducted with the hydrochloride of the base 'Ajmaline' (M.P. 158-60°) isolated according to method described by Siddique and Siddique.

The alkaloid is fairly toxic to lower forms of life. The minimum lethal dose in Kasauli strain of white mice is 0.0165 mg. per gramme. The minimum lethal dose varies between 0.4 to 0.5 gm. per kilogram of toads. Cats show a distinct fall of blood pressure with 5 mgm. of the drug injected intravenously. With higher doses, e.g. 10-15 mgm. the blood pressure becomes irregular. The auricles are inhibited earlier than the ventricles. The isolated mammalian heart is slightly stimulated with weak dilutions but is definitely depressed with stronger concentrations. Respiration is usually slowed. The central nervous system and reflexes appear to be inhibited with small doses.

34. The pharmacological action of 'Thevetin'—a glucoside occurring in *Thevetia nerifolia*, Juss. (Yellow oleander).

R. N. CHOPRA and B. MUKHERJEE, Calcutta.

Thevetia nerifolia, N.O. *Apocyanaceæ* is met with in the plains all over India and is widely grown in gardens for its beautiful yellow flowers. The seeds of this plant have long been known to be highly poisonous and have been very commonly employed for suicidal and homicidal purposes. De Vrij (*N. Tijdschr. Pharm.*, 1884, 138; *Pharm. Jour.*, 1881, 12, 457) first isolated a white crystalline glucoside from the kernels of the seed to which he gave the name 'thevetin'. Later B. B. De and Choudhury (*Cal. Univ. Thesis*) and R. Ayyar (*Proc. Ind. Sci. Congress*, 1928, p. 32) obtained the glucoside in a pure crystalline form. The present investigation was undertaken with a view to find out the pharmacological, toxicological, and therapeutic properties of thevetin, which is one of the active principles of yellow oleander.

Thevetin is not poisonous to *Paramæcium caudatum* or helminths from the intestinal tracts of cats and dogs. It is, however, definitely toxic to frogs, white mice, guinea-pigs, and cats. The minimum lethal dose varies from 0.15 to 0.3 mg. per kilo in frogs, 0.003 to 0.004 mgm. per kilo of white mice, 0.015 mg. to 0.024 mg. per kilo of guinea-pigs and 0.14 mgm. per kilo of cats. Thevetin has no irritant action locally on the conjunctiva or the skin or the subcutaneous tissues. It has no inhibitory action on the digestive enzymes. It has little or no direct

effect on the respiration but it has a distinct stimulant effect on the plain muscles of the intestine, urinary bladder, virgin uterus, and the blood vessels. The most important effect of thevetin is its stimulant action on the circulatory system in general and the action resembles in many respects the drugs belonging to the digitalis group. The glucoside, on account of its marked cardiotonic properties, should be a potent therapeutic agent, but the margin between the therapeutic dose and the toxic dose appears to be too narrow to warrant its safe administration clinically.

35. A study of the preparation of an efficient extract of Kurchi.

A. B. GHOSE, Calcutta.

1. Besides the specific action of alkaloids in Kurchi the tannins, mucilage, and resinous matters are presumed to act favourably on dysentery.

2. If this assumption is to be given any consideration then an alcoholic extract, besides containing reasonable amount of alkaloids, should also contain considerable quantities of tannins and resinous matters.

3. An extract with 60% alcohol satisfies all these demands.

4. An extract with 95% alcohol also fulfils these requirements. But the proportion of the extractive matter is comparatively low as some water-soluble matters are eliminated at this strength.

5. Preference between the two preparations is thus a subject of investigation for the clinicians.

36. The action of quinine on a hæmolytic system *in vitro* and its bearing, if any, on the mechanism of black-water fever.

P. N. BRAHMACHARI, R. K. BANERJEA, and U. N. BRAHMACHARI, Calcutta.

The present paper shows that solutions of quinine bihydrochloride or hydrochloride in strengths not having any direct hæmolytic action on red corpuscles inhibit hæmolysis in a hæmolytic system. If, therefore, in the hæmolysis of blackwater fever following administration of quinine, a hæmolytic system plays a part, then quinine hydrochloride or bihydrochloride would inhibit hæmolysis in that system, so far as experiments *in vitro* prove. Whether, at the same time, quinine helps in the development of a hæmolytic system in a susceptible individual, the authors are at present unable to say.

37. The action of certain quinoline compounds on paramœcia.

P. N. BRAHMACHARI, R. K. BANERJEA, and U. N. BRAHMACHARI, Calcutta.

The present communication is a continuation of previous series of papers on the action of certain quinoline compounds on paramœcia investigated by the authors and which were published in the *Journal of Pharmacology and Experimental Therapeutics*, (1) Vol. XXXIX, No. 4, August, 1930, (2) Vol. XLI, No. 3, March, 1931, and (3) Vol. XLIV, No. 4, April, 1932. It gives a record of their observations on a fourth series of quinoline compounds, most of which are new, and the chemistry of which have either been published or are under publication in the *Journal of the Indian Chemical Society*.

The following compounds are described in this series :—

Action of certain quinoline compounds on paramaccia.

	Strength.	Effect on Paramaccia.
1. Allyl-8-amino-quinoline-hydrochloride.	1 : 2,000 1 : 10,000	Death in 5 minutes. No death in 1 hour.
2. Allyl-thio-carbamino-8-amino-quinoline hydrochloride.	1 : 2,000 1 : 10,000	No death in 1 hour. No death in 1 hour
3. 6-methoxy-8- β -dimethyl-amino-isopropyl-amino-quinoline dihydrochloride.	1 : 2,000 1 : 10,000	Death in 14 minutes. No death in 1 hour.
4. 6-methyl-8- β -dimethyl-amino-isopropyl-amino-quinoline-dihydrochloride.	1 : 2,000 1 : 10,000	Death in 1 hour. No death in 1 hour.
5. 2-methyl-6-methoxy-8- β -dimethyl-amino-isopropyl-amino-quinoline dihydrochloride.	1 : 2,000 1 : 10,000 1 : 20,000	Death in 28 minutes. Death in 1 hour. No death in 1 hour.
6. Lactyl-8-amino-quinoline-hydrochloride.	1 : 2,000 1 : 10,000 1 : 20,000 1 : 40,000 1 : 80,000	Death in 12 minutes. Death in 28 minutes. Death in 35 minutes. Death in 1 hour. No death in 1 hour.
7. β -hydroxy-propyl-8-amino-quinoline hydrochloride.	1 : 2,000 1 : 10,000	Death in 45 minutes. No death in 1 hour.
8. 6-ethoxy- β -hydroxy-propyl-8-amino-quinoline-hydrochloride.	1 : 2,000 1 : 10,000	No death in 1 hour. No death in 1 hour.
9. 6-ethoxy-lactyl-8-amino-quinoline hydrochloride.	1 : 2,000 1 : 10,000	Death in 18 minutes. No death in 1 hour.
10. 6-methoxy-8- β -diethyl-amino-isopropyl-amino-quinoline dihydrochloride.	1 : 2,000 1 : 10,000	No action in 1 hour. No action in 1 hour.
11. 8-(β -piperidino-isopropyl-amino)-quinoline dihydrochloride.	1 : 2,000 1 : 10,000 1 : 20,000 1 : 40,000 1 : 80,000 1 : 100,000	Immediate death. Death in 2 minutes. Death in 10 minutes. Death in 11 minutes. Death in 15 minutes. Death in 35 minutes.

38. The intensive treatment of kala-azar with urea stibamine.

U. N. BRAHMACHARI, A. R. MAJUMDER, and R. B. DE,
Calcutta.

In this paper a series of cases of kala-azar are described cured by the intensive treatment with urea stibamine given intravenously on successive days in the following hospitals: (1) Carmichael Medical College Hospital, Calcutta, (2) Chittaranjan Hospital, Calcutta, and (3) Campbell Hospital, Calcutta. There were no untoward symptoms and temperature came down to normal after 1 or 2 injections. The number of injections was about 10. The total amount of urea stibamine required ranged from 1.2 g. to 1.35 g. The doses were 0.05 g., 0.1 g., 0.15 g., 0.2 g. Some of the doses were repeated.

The authors recommend that in suitable cases this intensive treatment should be adopted. One remarkable feature in this form of treatment was that the total amount of urea stibamine required for a cure in some of the cases was as low as 1.2 g. and in others less than 1.5 g. This would reduce the cost of treatment to a considerable extent. This is of much importance from an economic standpoint in the treatment of the disease where its mass treatment has to be taken into consideration by any Government as a prophylactic measure in endemic areas of kala-azar.

39. Treatment of kala-azar with intramuscular injection of sodium sulphomethyl stibanilate.

U. N. BRAHMACHARI, Calcutta.

A series of cases of kala-azar are described by the author treated successfully with intramuscular injection of sodium-N-phenyl-glycine-amide-4-stibinate. The compound is sodium-methylene-sulphonic acid derivative of stibanilic acid. The results of treatment were very satisfactory.

The toxicity of sodium sulphomethyl stibanilate is low. Its maximum tolerated dose is 0.4 per kilo of body weight in the case of white rats given intravenously. Generally speaking, no local or constitutional symptoms have been observed after its use. It has been injected up to a dose of 0.4 g. One injection of 0.5 g. was given to one patient without any untoward results. In one case complicated with nephritis, cedema, and epistaxis, no untoward results followed its use. Originally, the compound was used in doses of 0.1 g. to 0.2 g. intramuscularly, but the author has observed that the dosage can be increased in an adult from 0.2 g. to 0.4 g. without any constitutional symptoms. It has been used every other day in some cases and twice a week in others.

40. Observations on the therapeutic value of thio-sarmin in the treatment of syphilis in the Voluntary Venereal Hospital, Calcutta.

LT.-COL. A. DENHAM-WHITE, U. N. BRAHMACHARI, and
B. B. MAITY, Calcutta.

A series of thirty cases of various stages of syphilis and its manifestations have been treated with thio-sarmin and the results are compared with those of other arsenobenzene compounds. It has been found that the effect on the Wassermann reaction is remarkable in the case of thio-sarmin as the largest number of cases showing negative Wassermann reaction was noted after treatment with this drug, as compared with other arsenical compounds.

In compiling this paper the authors have not in any way selected cases for treatment as being likely to respond, but each case was taken in the order of admission irrespective of the gravity of disease or nature of symptoms. All cases have been positive in blood reaction and without exception the lesions have been gross and extensive. Side by side with thio-sarmino treatment, other cases have been undergoing treatment with other preparations. The advantages noted clinically are (i) absence of reaction in cases treated with thio-sarmino. The temperature hardly ever rises, and there is practically no pain. There have been no netritoid crises, nor anaphylactic conditions and hitherto no arsenical dermatitis. The drug may be regarded as one of the most innocuous at present in use, its lack of toxicity being most marked in comparison with its high efficacy. It appears to be, so far, most suitable both for hospital and private use. (ii) Furthermore, the rapidity with which symptoms disappear compares very favourably with other preparations. (iii) It has been observed from experience in this hospital that the ordinary Indian female patient is intolerant of novarsenobillon in doses over .45 gm. and it is the authors' practice never to exceed this. The usual onset of dermatitis when it occurs is after the 4th injection or if the .45 gm. has been exceeded. With thio-sarmino the maximum dose has been up to .6 gm. without the slightest effect. It is to be remembered that the dosage of the arsenical compounds, such as novarsenobillon, neo-salvarsan, etc., has been based on the physical characteristics of the European and it is now known that the Indian female cannot tolerate a dose well-borne by her European sister. This does not, however, seem to apply in the case of thio-sarmino. The authors have observed no case in which the Indian female has shown intolerance even in the higher doses. It therefore appears clinically that it is of a comparatively low toxicity.

VETERINARY.

41. Etiology of kumri. Preliminary note.

P. G. MALKANI, Patna.

Various theories have been put forward from time to time regarding the etiology of *kumri* but hitherto none has been found to be satisfactory. In post-mortem examinations detailed by previous workers no mention has been made of schistosomes. At this laboratory careful examination of the liver and portal vessels during the course of post-mortem examinations on two *kumri* ponies (one destroyed in an advanced stage of the disease and another allowed to die in equally advanced stage) has revealed the presence of schistosomes in both cases. As a result of this finding treatment of an advanced case of the disease with sodium antimony tartrate has been attempted and this too has yielded encouraging results. These observations point to the possibility of *kumri* being a form of schistosomiasis. The seasonal (rainy) and regional (low-lying districts) distribution of *kumri* make the schistosomiasis theory very attractive. Attempts are now being made to test this theory at this laboratory. Contemporary workers may also be on the lookout for schistosomes in cases of *kumri* and try the tartar emetic treatment whenever they get an opportunity.

42. Discovery of the cause of nasal granuloma. Preliminary report.

P. G. MALKANI, Patna.

The etiology of nasal granuloma in cattle has engaged the attention of veterinary research workers for the last 10 years or so. Different explanations have been given from time to time but the most plausible case has been made out by Prof. Krishnamurti Iyyar against an

'Actinomyces-like fungus' which is alleged to be present in the polypoid growths seen in the nasal cavities. Work carried out at this Research Laboratory has however shown that the actinomycotic theory is no longer tenable. As a result of the discovery of sections of schistosomes during histological examination of the growths, of the discovery of actual parasites in the fixed growths and during post-mortem examination, and lastly of the discovery of the characteristic spindle-shaped eggs and ciliated embryos (miricidia in direct cover-glass preparations of the nasal discharge from all affected animals, it is now announced that nasal granuloma in cattle is a form of schistosomiasis and that the species of schistosome responsible for the condition is probably *Schistosoma spindalis* Montgomery, 1906. This schistosome theory explains most satisfactorily the various observations made in connection with this disease, namely, its regional and seasonal occurrence, the nature of the lesions, the unsuccessful attempts of previous workers at direct transmission and finally the uniformly successful treatment with tartar emetic.

43. A rapid method for evaginating the scolices in parasitic cysts.

P. G. MALKANI, Patna.

Difficulty was being experienced in evaginating the scolices of parasitic cysts for the purpose of studying the suckers and hooks. Experiments were therefore carried out to find out a rapid method for this purpose. The cysts used for these experiments were *Cysticercus tenuicollis* and *Cysticercus bovis*, and the following methods were tried: (1) Application of pressure to the caudal vesicle, (2) keeping the cysts in physiological saline at room and incubator temperatures, (3) keeping the cysts in diluted bile (obtained from a carcass) both at room and incubator temperatures, (4) keeping the cysts in dilutions of sodium taurocholate at room and incubator temperatures, (5) keeping the cysts in a solution of sodium glycocholate both at room and incubator temperatures, (6) keeping the cysts in Ringer-Locke solution at both room and incubator temperatures.

The pressure and saline methods were found to be unsatisfactory. With Ringer-Locke solution at incubator temperature (37°) evagination occurred after a long time (30-48 hours); with diluted bile the evagination was more rapid and certain; with glycocholate the evagination was less rapid than with bile; with sodium taurocholate the evagination was most rapid and the time taken seemed to vary with the concentration.

From these experiments it would appear that surface tension plays some part in the process of evagination under natural conditions.

44. A new blood fluke from an Indian tortoise, *Trionyx gangeticus*.

G. S. THAPAR.

Hermaphroditic trematodes from the blood vessels of the turtles are included under the family Spirorchidae and are represented by several genera. A good deal of work has been done on this group in the West, but so far as I am aware nothing is known about it from India. In the present communication a new genus of blood flukes is described from *Trionyx gangeticus*.

The genus is characterised by the following features:—

1. Absence of the cuticular spines over the body;
2. Presence of protrusible suckers;
3. Absence of a pharynx;
4. Presence of a bicornuate excretory bladder;

5. Presence of ovary between the two testes, and all three are lobed structures;
6. Dorsal and sinistral position of the genital pore;
7. Position of both seminal vesicle and cirrus anterior to the testes; and
8. Presence of extensive vitellaria.

The paper concludes with a discussion on the systematic position of the genus and it seems to connect together the two genera—*Hapalotrema* and *Hapalorhynchus*—of the subfamily Hapalotremine.

The name suggested for this new trematode is *Rhynchotrema indica*, *n.g.*, *n. sp.*

45. The infectivity of milk in rinderpest.

P. C. BANERJI, Muktesar.

An experimental herd is maintained at the Imperial Institute of Veterinary Research, Muktesar, which consists of both male and female animals immunised against rinderpest. These animals are subjected to test at different intervals with a dose of virulent blood to gauge whether their immunity against rinderpest has waned. An opportunity was afforded to undertake a series of experiments to determine the infectivity of milk when such cows reacted to the virus inoculation. A certain number of healthy hill bulls were either drenched or sub-inoculated with milk derived from infected cows when the latter had fully developed the disease. Milk withdrawn from the 5th to 10th days from the date of virus inoculation proved to be infective with a dose of 10 c.c. on sub-cutaneous inoculation, but gave negative results when administered orally even with as large a quantity as 500 c.c. It was concluded that milk from affected cases of rinderpest ceased to be infective from the 12th day onwards from the date of virus inoculation.

46. Observations on *Calliphora erythrocephala*, Mg., with remarks on the diagnostic value of the anterior spiracles of the larvæ of myiasis-producing flies.

S. K. SEN and MUHAMMAD YAKUB, Muktesar.

The life-history and habits of *Calliphora erythrocephala*, although widely reported upon from many different parts of the world, are little known in the Indian region, this being doubtless due to the fact that, in India, *C. erythrocephala* has been recorded only from the northern hill stations, where arrangements for entomological work do not exist to the same extent as they do in the plains. The present paper embodies a few observations upon these flies at Muktesar, where they are of common occurrence during the cold weather, being particularly noticeable in the post-mortem house attached to the Institute. The flies were bred out from eggs deposited in captivity, the larvæ having been carefully enclosed with meat in paper bags, to keep off roving flies, in the manner recommended by Patton (1921-22). At a temperature of about 23°C., the incubation period for the eggs was found to be about 24 hours, whilst the larval and pupal stages were each completed in about 10 days.

In the course of observations upon this and other species of Calliphorid flies, it was noticed that the number of papillæ in the anterior spiracles in the same species of larva varied within such wide limits as to render them undependable for the purpose of distinguishing one species of Calliphorid from another.

47. Acid-fast infections in cattle and the import of their relationship in diagnosis.

CAPT. S. C. A. DATTA, Muktesar.

In connection with certain experimental work, two bullocks, which were found to be infected with Johne's disease as a result of testing with avian tuberculin and examination of rectal smears were brought up to Muktesar from Bihar in 1930. After a sojourn of one year at Muktesar, these two animals were destroyed for detailed *post-mortem* examination. The result of examination of the tissues by culture, animal inoculation and histological examination showed them to be definite cases of tuberculosis, the original diagnosis of Johne's disease being still confirmed by the specific organisms in bowel smears in one case only. A further case was provided by the Army Remount Depot, Mona, in which a bovine was confirmed to be affected severely with both organisms since the lung lesions were definitely of milary tuberculosis and the intestines were unmistakably affected with Johne's disease.

Although reports on double infections such as these are not at all rare in the literature, the general belief seems to be that these are quite infrequent in occurrence. The findings in these cases have been discussed, since these conjoint infections may be a disturbing factor in the correct interpretation of the diagnostic tests. The properties which this important group of organisms has in common, such as staining affinities, morphological features, cultural requirements, and reaction to avian tuberculin have been considered, to interpret if possible the frequency of double infections, such as the above cases.

48. Experiments upon the toxicity of Greenland cryolite for cattle and buffaloes.

P. C. BANERJI and D. A. MUNRO, Muktesar.

Experiments were undertaken at the instance of the Imperial Council of Agricultural Research to estimate the toxicity of the so-called 'Greenland cryolite' for cattle and buffaloes, in view of the possibility of grazing animals having access to this material while it is being used in antilocus field operations in India. Greenland cryolite is a fluoride of aluminium and sodium and occurs as a natural deposit on the coast of Greenland. For the purpose of the present experiments, however, a synthetic form of this material was used, this having been found better adapted as an insecticide than the natural product. The salt was fed to buffaloes and hill bulls up to a dose of 1 lb., without any ill effects being noticed in any of these animals.

49. On a new species of *gongylonema* (nematoda) from the domestic fowl.

G. D. BHALERAO, Muktesar.

A new species of *Gongylonema*, *G. sumani*, parasitic in the crop of a fowl at Lucknow has been described. It is allied to *G. ingluvicola* but it differs from it in the arrangement of the cuticular bosses at the anterior end, the left spicule being much smaller, the presence of a gubernaculum and in the absence of a cuticular plate-like shield round the excretory pore. This is the second member of the genus hitherto known to be parasitic in the fowl.

50. On a few nematodes parasitic in goats at Muktesar.

G. D. BHALERAO, Muktesar.

A new species, *Setaria buxi*, has been described, which forms the first record of a member of the genus *Setaria* parasitic in goats. The species is allied to *S. labiatopapillosa*, *S. equina*, and *S. poultoni*, but it can be distinguished from these on account of its elevated peribuccal ring with its walls bearing tooth-like processes projecting into the lateral notches, the dorso-ventral lips being without a notch, and the tail having two pairs of papillæ: one large and the other very small.

The species *Oesophagostomum asperum* has been recorded for the first time in India. The species *Gongylonema verrucosum* has been hitherto known to be a parasite of the sheep, ox, or zebra only. This is therefore recorded, for the first time in the world, from a new host, the goat.

51. On two unrecorded nematodes from the abomasum of cattle in India.

G. D. BHALERAO, Muktesar.

Up to the present time only one species of *Hæmonchus* has been known to occur in India, viz. *H. contortus*. The author has discovered the species *H. similis* Travassos, 1914, on many occasions from the abomasum of cattle at Muktesar. The species has been redescribed and some interesting variations, particularly in respect of the position of the vulva, have been noted.

Only one species of *Capillaria* has been known to occur in cattle, viz. *C. bovis* Schnyder, 1906, and even this is very insufficiently known. The author has described a new species of this genus which is designated *Capillaria bilobata*. It is characterised as follows:—

Male.—Length 10.1–16.5,¹ thickness 0.05–0.083. Oesophagus 5.2–8 long. Spicule striate 0.19–0.24 long. Spicular sheath consists of a terminal lobe which is like an inverted bell and the other pear-shaped lobe. Posterior extremity alate and expanded into a bursa-like structure.

Female.—Length 14–21.3, thickness 0.072–0.085. Oesophagus 6.5–9.4 long. Vulva 0.055–0.075 behind the posterior end of oesophagus. Eggs lemon-shaped, 0.033–0.053 × 0.014–0.021.

52. Actinomycosis in a buffalo heifer.

CAPT. S. C. A. DATTA, Muktesar.

The subject of actinomycosis has received very little scientific attention amongst veterinarians in this country and the general belief has been that the condition is not at all frequent. Although certain intractable diseases of animals in India, such as bovine nasal granuloma, bursati and bovine lymphangitis, were ascribed from time to time to streptothrix organisms, reports on genuine cases of actinomycosis of animals have been very few indeed. Poase (1891) described an outbreak amongst 11 buffaloes of various ages in the Punjab, and Krishnamurti (1927) describes a growth on the shoulder blade of a buffalo and another in a bovine.

The present case concerns a buffalo heifer of Delhi breed, belonging to a resident of Hyderabad, Sindh. The growths in this case were situated on the parotid glands of both sides of the neck, which were surgically removed and the case treated with potassium iodide with apparent success. Histological examination revealed Gram-fast mycelia in the centre of the ray fungus' colonies.

¹ All measurements in millimetres.

This case has been considered as worthy of report since actinomycosis in the buffalo has not been described before, apart from the two reports mentioned above and in order that the attention of field workers may be drawn to the occurrence of this condition in India.

53. Histopathological studies on 12 cases of helminthic granuloma of the equine skin.

CAPT. S. C. A. DATTA, Muktesar.

The results of histopathological studies on, what is believed to be, the first cases of helminthic granuloma of the equine skin to be discovered in this country are recorded in the paper. From an analogy with the findings in related conditions, such as *summer sores* in Europe, *esponja* in Brazil, in which a verminous habronemic origin has been generally accepted, *bursati* in India has been suspected to be due to a species of *Habronema* (Sen, 1927) but confirmation has been consistently not forthcoming. The material for the present studies was provided by specimens of tissue, the specimen being removed from the neck of a horse and forwarded as *bursati* lesions from Ferozepur. The histological findings in the first case are of great interest, for, apart from the usual characters of *bursati* tissue, namely, an inflammatory granulation tissue associated with pronounced eosinophilia, the capillaries and larger vessels have revealed a severe thrombo-angitis with the larvæ of a nematode worm enclosed in the thrombus material. The sequence of events in the development of individual lesions has been studied. The most outstanding and fundamental changes have been observed in the blood-vessels, the two extreme pictures of the lesions being a mild endothelial lesion and a pronounced 'phlebolith' formation. The changes in this case at least were due to an infection contracted from internal sources since the blood-vessel lesions in general were noticed as advancing from inside out and because the parasites were invariably restricted to the inside of intact vessels.

Expert helminthological opinion was obtained from Mr. G. D. Bhalariao, M.Sc., who was inclined to consider certain spine-like processes on the worms as the striations or ridges characteristic of *Habronema* larvæ.

It is important to record here that in ten other cases of *bursati* material studied since, the worm larvæ have been constantly found, and these positive cases include samples of tissue received from such distant parts of the country as Assam, Hyderabad-Deccan, the Punjab, and the North-West Frontier Province. The histological features of *bursati* have been studied, side by side, with those of a definite case of cutaneous habronemiasis from Greece. The tissues from the latter were obtained through the courtesy of Messrs. Phéloukis and Knithakis. As a result of these studies, the Grecian condition was found to be identical in histological features and in the characters of the parasitic larvæ with *bursati*, as it obtains in India.

54. Serum proteins of hill bulls and their estimation by colorimetric method.

K. C. SEN and A. C. ROY, Muktesar.

In order to find out if Wu's colorimetric procedure (*J. Biol. Chem.*, 1922, 51, 33) is suitable for the determination of the serum proteins of hill bulls, a large number of experiments have been made and it has been observed that Greenberg's modification (*J. Biol. Chem.*, 1929, 82, 545) gives results in close agreement with Kjeldahl's method of determination, and is also reasonably rapid for routine work. In this connection some data regarding the amounts of the different protein fractions of serum in the case of a large number of animals, healthy as well as recovered from disease, are tabulated.

55. Observations on the use of plains buffalo calves as intermediaries in the propagation of rinderpest virus in plains calves of relatively low susceptibility with a view to conserving its maximum virulence.

V. KRISHNAMURTI AYYAR, Madras.

As compared to the Kumaon cattle in Northern India or to cross-breeds, cattle of the plains are said to possess a relatively moderate or low susceptibility to rinderpest.

Scheme for the opening of a second Institute for the preparation of Anti-Rinderpest Serum which was suggested in 1906 was abandoned on the ground of insufficiency of supply of susceptible cattle as virus producers.

In a Pusa bulletin published in 1922, Pool and Doyle have recorded that the reaction to rinderpest in Kumaon hill bulls was much earlier and more severe than in the Bareilly plains buffaloes.

No literature is available showing the effect of alternations of the passage of rinderpest virus in the buffalo and ox of the plains. The author had an opportunity to study these effects in the course of the preparation and supply of potent virus for use in Serum Simultaneous Inoculations in the Madras Presidency.

Between 12th September, 1928 and 1st March, 1929, 194 animals were used for the purpose, 71 being buffalo calves and the rest heifers, bull calves, and a bullock. 15 of the latter were cross-breeds. Of these 194 animals, 11 died of other causes, 173 reacted and the remaining 10 showed no reaction.

The original strain of the virus was obtained from the Superintendent, Serum Institute, Bangalore, and during the period in question the virus underwent 27 passages. The details of the reactions observed in the calves used and the intensity of the reactions are discussed in the paper.

The author admits that animals of the same breed and type may show differences in regard to susceptibility and, though such differences may affect the reactions, yet the observations of the reactions shown by the calves used indicate the possibility of maintaining the potency of the virus in the plains calves to the maximum virulence by suitable alternations of passages of virus.

This observation corresponds to what workers have experienced in respect of another virus disease of the bovines, viz. vaccinia, where the use of buffalo calves for passing the virus in preparing vaccine lymph in what is known as 'Nijland's cycle' is reported to have decidedly contributed to the conservation of the virulence in calves of the ox type and led to an improvement in both the yield and potency of the lymph produced.

The author suggests that it is possible that virulence might be maintained in severe outbreaks by similar *natural* alternations in the buffalo and the ox leading to heavy mortality. The author emphasises the importance of this aspect in the examination of several factors concerning the epizootiology of the disease.

56. Observations on the epizootiology of rinderpest.

V. KRISHNAMURTI AYYAR, Madras.

Literature on the epizootiology of the disease is scanty.

As a preliminary, the incidence of mortality in cattle from this disease in the Madras Presidency from 1904 to 1932 as revealed by the published statistics is examined.

A comparative study is made of its incidence in each district as well as in groups of districts either contiguous or similar in geographical and climatic conditions with reference to the following factors: density of cattle, main types or breeds of cattle, proximity to Indian States or

other provinces adjoining the Presidency, frequency of cattle fairs, cattle routes, grazing routes, grazing areas and their incidence, etc. Literature available on the viability of the virus, the views prevalent from time to time in regard to the origin and spread of the disease and preventive measures adopted from 1911 to 1932 in combating the disease are also referred to.

The study shows that no district has been free from this disease in any year during the period except during the official years 1914-15 and 1921-22, when no deaths were returned from the districts of Nilgiris and Ramnad respectively. It also shows that the disease appears in more or less an intense form in some years, is followed by a period of mildness and then assumes virulence subsiding again in somewhat regular intervals. The peak for each district, the intensity and periodicity of such peaks are discussed in the paper.

A very remarkable feature to be observed in respect of its epizootiology is the absence of correlation with any of the factors, such as the geographical position, as for instance, proximity to Indian States or other province, or the frequency of cattle fairs, or a high incidence of grazing, or cattle traffic, or grazing routes. Though these factors might contribute to the dissemination of the infection they do not appear to affect the phase of the disease in each district. Districts where cattle fairs were frequent and where there had been congregation of over 20 to 30 thousand cattle at each fair, have not suffered any worse than those where these had been infrequent or less numerous. Nor have the incidence and the periodicity of the disease been found affected in such districts. Similar is the case with other factors also. With a view to finding out whether the variations noticeable in the various districts or groups thereof are observable as between the different taluks within the same district, an examination is made of the progress and incidence of the disease in one of the districts in the Presidency, viz. Chittoor district. The results of this examination do not materially differ from those observed in the study of district conditions. Similar results are obtained by a study of the phase of the disease in different villages in a taluk. Details of these examinations are given in the paper.

The possibility of the maintenance of virulence in the ox and the buffalo by *natural* alternations as suggested by the author in another paper is also referred to in respect of some of the outbreaks.

Charts and maps illustrating the several points discussed are appended to the paper.

57. A note on some preliminary experiments conducted in regard to the method of infection in anthrax.

V. KRISHNAMURTI AYYAR and M. NOOR AHMED, Madras.

In a paper read by one of the authors, Krishnamurti Ayyar, at the Seventh Far Eastern Congress of Tropical Medicine in Calcutta in 1927, evidence was adduced by him of the high extent of infection in industrial materials examined by him. It is also not uncommon to find carcasses of animals dead of anthrax handed over unknowingly by owners to chamars who skin, handle, and even utilise them to a certain extent as food. In spite of these factors favourable to the spread of infection, occurrence of the disease among men that come up to the notice of the State authorities is surprisingly very rare. Even among cattle or sheep kept under identical conditions, fed and stalled together, the disease has appeared only in a few. To the knowledge of the authors, sporadic cases have occurred in elephants, horses, and even in a lion, and curiously enough, the disease has not affected other animals kept in the same premises and fed under the same conditions as infected animals. This phenomenon suggests the existence of certain factors which prevent the occurrence of infection on a wide scale and as a preliminary to the

study of these factors, certain experiments following the more common mode of natural infection, viz. scarification and ingestion were conducted by the authors in the most susceptible animals available, viz. guinea-pigs.

Three different strains of cultures were used in the experiments. The procedure adopted was to infect one or more guinea-pigs with massive doses of millions of bacilli and spores and to scarify one or more others with infinitely smaller amounts of the same culture; guinea-pigs that escaped infection from ingestion or scarification in one test were again tried with either the same strain or a different strain. The results obtained have not been uniform and they are discussed in the paper.

Blood was also drawn from the heart of six guinea-pigs fed with the culture at intervals varying from two to five days after infection. Neither did the guinea-pigs succumb to the infection nor was their blood as revealed by cultural tests and animal inoculations found infective.

Literature recorded by other workers on the subject is reviewed in the paper.

58. Further studies in Cancer in animals.

V. KRISHNAMURTI AYYAR and R. VENKATARAMAN, Madras.

In a paper read by one of the authors, Krishnamurti Ayyar, at the 14th session of the Indian Science Congress held at Lahore in 1927, he brought forward evidence of the high incidence of Cancer in animals and stated that it was as high as that observed in man in the Madras Presidency.

Subsequent to that, a Reuter's communication dated 6th December, 1929, announced the discovery, in certain villages in Westmoreland, of the great prevalence of all types of malignant neoplasms in animals by the Cancer Commission under the guidance of Dr. Louis Sarnbon. The finding of the Commission is that the discovery has opened out wide possibilities and that without the knowledge of the disease in animals, it is impossible to understand and, much less, control the disease in man.

The authors continued a further study of the disease which shows that in the Madras Presidency it is wide-spread. Details of over three hundred cases are given in the paper of which forty-five occurred in cows.

59. Canine filariasis—a short review of the Literature.

S. C. ROY, Calcutta.

A few cases of dermatosis have been observed in the dog in the morbid fluids from the skin of which the presence of embryo nematodes has been observed. Some workers have considered the parasites to be sometimes *Microfilaria*, at others *Rhabditis*. The microfilaria would be of the same species as those which are so frequently found in dogs' blood; these are the embryos of *filaria immitis* which in the adult state live in the right heart, and pulmonary artery, but may also be found in the peripheral circulation. Rivolta in 1868 refers to a young pointer dog which had a hairless red herpetic humid and ulcerated patch covered with crusts. A microscopical examination of the detritus showed embryos of *filaria medinensis*. G. B. Ercolani in 1875 found dead filarial parasites in the subcutaneous connective tissue.

Rivolta, further in a memoir in 1877 notices a few dogs, suffering from filariasis. The clinical symptoms of them might have been referred to Dumb rabies, hæmorrhage from the lungs, euteritis and eclampsia. He confirmed his diagnosis, with the examination of the blood.

The author found in the peripheral circulation of a few dogs *filaria immitis*, *filaria bancrofti*. The dogs were exhibiting the symptoms of urticaria like eruptions all over the body. The etiology of this urticaria may be described as discharging toxin into the system by adult worm in the process of reproduction of the drugs employed in canine filariasis, Atoxyl or Tartaremetic might hold superior to other drugs.

60. Some observations on the bacteriological study on Bengal cattle in Calcutta slaughter-house.

S. C. ROY, Calcutta.

The cervical, Tracheobronchial, and mesenteric lymphatic glands of cattle were collected by the author from the Calcutta slaughter-house (Tangra). Smears were taken from these glands and examined with Ziehl-Neelsen method. Out of six cases two have been found to be positive slides having acid-fast organism. On animal inoculation to guinea-pig the author has noted the non-pathogenicity of these organisms. Again, in the hæmatological studies of another set of cattle from the same slaughter-house, the author has found babesia bigeminum, surra parasite, and sarcosporidia. Besides these, anæmic changes were also not uncommon in them. The author has observed the majority of the cattle in poor condition. Suspension of rumination, dullness of the appearance, and prominence of the ribs.

BACTERIOLOGY, PARASITOLOGY, AND MISCELLANEOUS.

61. Aqueous extract of young bamboo shoots and leaves—
Some of their insecticidal and larvicidal properties.

LT.-COL. A. D. STEWART and V. N. MOORTHY, Calcutta.

It was observed in certain guinea-worm infected villages that bamboo leaves were commonly used as a prophylactic against guinea-worm infection. Cold poultices of young bamboo shoots are the common remedy adopted in these areas for the dislodgement of guinea-worms, from the ulcers.

Experimental observations made so far show that the aqueous extract of the young bamboo shoot has a definite lethal action on guinea-worm embryos. In addition, it has been noticed that it has also a lethal action on the larvæ and imago of both house flies and mosquitoes.

These 'cyclopedocidal', larvicidal, and insecticidal properties appear to be due to the HCN liberated by the decomposition of cyanglucoside present in bamboo shoots in presence of water and also to another substance, the nature of which is still under investigation.

Experimental results, showing the amount of free HCN liberated by the decomposition of cyanglucoside of bamboo shoot and its relative effect on mosquito larvæ as compared with the KCN solutions of different strengths, have been appended.

62. The question of filtrability of the tubercle bacillus.

M. B. SOPARKAR and J. C. S. DHILON, Bombay.

There is a considerable disagreement between different workers on the question of the existence of a filtrable phase of the tubercle bacillus. Calmette and his associates principally claim to have proved its existence while Petroff, Griffith and others have obtained negative results. A series of experiments were performed to study this problem and tuberculous tissues, cultures and pathological material were employed for filtration. The emulsion was filtered through Chamberland L 3 candles under controlled conditions and the filtrates were inoculated into guinea-pigs. In the first series of thirty-two experiments only 3 out of 105 animals showed acid-fast bacilli while the rest gave negative results. In the second series of ten experiments the method was somewhat modified and serial passages were made of the material from guinea-pig to guinea-pig at definite intervals. Acid-fast bacilli were, in this series, detected in all cases in different passage animals and strains of tubercle

bacilli in pure culture were successfully isolated in six out of ten experiments. The possibility of these positive findings being due to spontaneous infection was ruled out by the results of control passage experiments. The characters of the strains isolated were further studied. In three cases they were found to differ markedly from the original strains indicating biological changes in the bacillus.

63. Fatal Flexner bacillus infection in an anthropoid ape (*Hylobates hoolook*).

B. M. DAS GUPTA, Calcutta.

Importance of determining whether the pathogenic agents of disease in man and apes are or are not identical. Thus Dobell has shown that *Entamoeba histolytica* parasitises monkeys of the genus *Macacus*, and that the monkey strain is just as pathogenic to kittens as is the human one.

A *Hylobates hoolook*, originally captured near Gauhati in Assam, and well acclimatised to Calcutta conditions was purchased from the Zoological Gardens, Alipore, and inoculated with a strain of monkey malaria originally derived from a *Macaca irus*. After an incubation period of ten days a mild attack of malaria resulted with very scanty parasites in blood films. This was cured with quinine. Later, an injection of 5 c.cm. of infected blood from a human case of quartan malaria was injected into the ape, but no infection resulted.

Two months later, the ape commenced to pass dysenteric stools. These showed the cell exudate characteristic of bacillary dysentery, but with scanty trophozoites of *E. histolytica* containing ingested red corpuscles also present. Cultures on MacConkey's medium gave a rich growth of Flexner's bacillus, with typical sugar and agglutination reactions. Cultures in Cleaveland and Sanders' medium gave a growth of *Trichomonas* and scanty *E. histolytica*. With bacteriophage treatment there was temporary improvement, but the animal finally died on the seventh day of illness. At autopsy the liver was found to be congested and enlarged, with hyperæmic patches and superficial ulceration in the lower part of the colon. The contents of the cæcum contained actively motile *Trichomonas*, but no *E. histolytica* could be detected. Sections of the gut showed a typical picture of bacillary dysentery, with also an encysted *Hymenolepis nana*.

A *Macacus rhesus* was now fed with cultures of the Flexner's bacillus isolated from the hoolook, but failed to contract the infection. A second *M. rhesus* was further fed with a strain of Flexner's bacillus of human origin, but also failed to take. Further experiments with *Hylobates hoolook* were impossible owing to the prohibitive cost of these animals.

The experience shows that anthropoid apes may become naturally infected with bacillary dysentery.

64. The choice of a counterstain in the Ziehl-Neelsen method.

A. C. UKIL and S. C. CHOWDHURY, Calcutta.

100 consecutive samples of T.B. positive sputa were stained by the Ziehl-Neelsen method, counterstaining one of the slides of the same pair of smears with methylene blue and the other with S.S. picric acid (aqueous). From the data arranged in a table, it will appear that the picric acid counterstaining gives a much higher count, as much as double in some cases, of acid-fast bacilli than in preparations counterstained with methylene blue. In five cases in which no acid-fast bacilli could be found in over 200 fields in the methylene blue stained smears, they could be detected by the latter method. For some years we have had very satisfactory result with staining one film by Gram's method (for secondary bacterial flora) and the other by the Ziehl-Neelsen method using picric acid as the counterstain.

65. Some chaetopod worms in particular relation to man.

C. A. STRICKLAND, Calcutta.

In this paper is given a short account of some records coming within the above title.

They were originally prompted by two cases reported in Calcutta of Polychaetes causing no harm to man.

66. Bacteriology of the tonsils.

N. A. AINGAR and N. G. CHOKKANNA, Bangalore.

A study of the nature of the organisms found in human tonsils, has shown that the most common present are *M. catarrhallis*, *M. tetragenus*, *S. aureus*, *S. albus*, *S. citreus*, and *B. pyocyaneus*. In diphtheria cases *B. diphtheriae* was also present. But in all the cases studied, no T.B. organisms could be isolated.

67. Treatment of phagedenic ulcer by the 'Lipovaccin Anti-phagedenique'.

CAPTAIN TALEC and DAMODARIN.

In the clinical aspect of phagedenic ulcer is well known and its causes well established, its treatment remained till now uncertain; proof: multiplicity and variety of medications used for it.

To these various treatments based almost on the discovery of arsenicals is added, these late years, a vaccine treatment due to the works of Pons who, starting from a spirochæte isolated in the buccal cavity of man, prepared a vaccine which stops the phagedenism in 4 to 5 injections.

This vaccine prepared now in the Laboratory of Lipovaccins is a polyvalent lipovaccin containing,

	per	2 c.c.
3 milligrams	of	<i>Spirochetum necrosans</i> ,
4 "	of	<i>Bacillus fusiformis</i> ,
30 millions	of	streptococci,
30 "	of	staphylococci,
30 "	of	pyocyanic.

Although rarely met in French India, we were able to study the action of this lipovaccin in nearly 20 cases. These ulcers are simply washed with lukewarm water and bandaged with gauze and aseptic cotton without any antiseptic.

Results have been really encouraging. The rapid formation of epidemic edges, sign of the cure, the stopping of phagedenism after the second or third injection constitute a success which we had never obtained so quickly by other treatments.

The dose of lipovaccin to be injected is 1 c.c. an injection.

The thermic reaction never rises high due to the slow absorption of microbes which are in oily suspension.

68. Keratomalacia and *plasma de quinton*.

P. GOVINDARAJASAMY.

It is a known fact that keratomalacia is one of the chief causes of preventive blindness in India. It is due to the deficiency in vitamine A. It is depicted easily by the corneal microscope, even in very early stage.

Cod-liver-oil rich in vitamine A, has been used till now for its treatment; but its administration is generally found difficult owing to the diarrhoea which is always present.

This has led us to use sea-water injection known as *plasma de quinton* which was found very effective in infantile diarrhoea and in athrepsia. It is injected subcutaneously, the doses varying accordingly to the severity of the cases.

The treatment of the cod-liver-oil along with the association of Plasma de Quinton has given very good results in the Hospital.

69. Ulcers of the cornea and auto-hemotherapy.

P. GOVINDARAJASAMY.

It need not be mentioned about the complications and sequelæ of corneal ulcers and especially *ulcus serpens* and hypopion ulcers.

The percentage of cures is low with all the classical treatment, cauterisation, antiseptics, milk injection, etc.

The author of this paper used in these cases auto-hemotherapy which gives much better results. The usual method of drawing blood from a vein of the patient is employed. The eyes are already washed and any lacrymal infection attended to; 1 c.c. of the blood is injected sub-conjunctivally as an ordinary sub-conjunctival saline. The local reaction is mild and not so strong as with cyanide. The very next day, there is immense relief and the pain and the infection subside; the injected blood is absorbed easily and the cicatricial tissue is not thick.

Therefore, this simple treatment can be used with success in all cases of corneal ulcers, so prevalent in India.

70. A preliminary investigation into the incidence and effect of tropical diseases complicating pregnancy.

A. L. MUDALIAR and K. NARASIMHA, Madras.

(1) Incidence. (2) Effect of tropical diseases on maternal mortality and morbidity. (3) Some of the common tropical diseases affecting pregnancy in Southern India. (4) Malaria—its effect during pregnancy at the various stages—prognosis—methods of treatment. (5) Kala-azar—its effect on pregnancy. (6) Helminthic infection in pregnancy—incidence, effects, prognosis, and treatment. (7) Some common bowel disorders affecting pregnancy. (8) Role of tropical hygiene in the reduction of maternal mortality and morbidity.

71. Anæmias of Pregnancy.

A. L. MUDALIAR and K. NARASIMHA, Madras.

(1) Methods of classification of anæmias. (2) Incidence of the different forms of anæmia according to race, age, and parity. (3) Clinical features of the different types of anæmias met with. (4) Effects of the anæmias on pregnancy and parturition. (5) Prognosis. (6) Methods of treatment adopted.

72. Incidence of skin diseases at Vizagapatam.

D. V. SUBBA REDDY, Vizagapatam.

The object of the paper is to draw attention to the variations in the incidence of common skin diseases in South India as compared with the experience in the temperate zone. Based on an analysis of 4,100 cases that attended the skin department of the King George Hospital, Vizagapatam, during the period of two and half years commencing from 1st January, 1929.

The proportion of dermatological cases to the general out-patient attendance. Leprosy forms 1.1% of the total out-patient number while all other skin diseases form only 3.2%. Comparative figures are given for General Hospital, Madras and Presidency.

The relative frequency of different skin diseases grouped according to Pusey's classification: Tables, Charts, and Graphs.

Among the common diseases, leprosy accounts for 25.6%, scabies 20%, ring-worm 10.96%, eczema 6%, dermatitis 4.7%, erythrasma 2.3%, impetigo 2%, syphilis 2%, sycosis 1.95%, seborrhoea 1.8%, furunculosis 1.6%, hyperpigmentation 1.5%, leucoderma 1.2%, tinea versicolor 1.2%, and warts 1%. Among less frequent diseases, psoriasis and urticaria contribute less than 1% each. Among the rarer diseases are dermatitis herpetiformis, pemphigus, molluscum fibrosum, erythema multiforme, exfoliative dermatitis, herpes zoster, alopecia areata, and dermatitis venenata. No cases of occupational dermatitis were noted. Among the diseases peculiar to tropics, one case of mycetoma, one of veld sore, 16 cases of keratoma plantaris sulcatum, and 10 cases of lichen spinulosum tropicum were registered. A statement showing the incidence of common skin affections in Madras General Hospital is also given. A comparison is instituted with the statistics of Western countries.

Discussion of the possible regional, solar, atmospheric, dietary and other modifying influences accounting for the variations in incidence. Recent literature on experimental work and clinical observations explaining variations. Graphs.

Plea for encouragement of dermatology in South India.

73. Skin temperatures in health and disease with special reference to the tropics.

D. V. SUBBA REDDY, Vizagapatam.

Skin temperature is of considerable interest to the physiologist and clinician.

Definition. Significance of skin temperature. Estimation of skin temperature is the easiest method of estimating the circulatory condition of the skin. Skin temperatures and basal metabolic rate. In interpreting changes in skin temperature, the body temperature must also be taken into account. Comparative readings on symmetrical points are of value. By estimating skin temperatures under certain experimental procedures, the vasomotor activity of the limbs is roughly determined.

A short historical review of the previous work.

Methods of measuring skin temperatures are discussed. The only two methods for clinical use are the thermometrical and thermo-electric couple. The disadvantages and the different 'techniques' of thermometric methods. Merits and demerits of the T.E. Couple. Benedict's and Lewis's practical forms of apparatuses for this work.

Skin temperatures in health. Foged's observations summarised. Tabular statements. Graphs. Skin temperature of head and trunk is higher than that of extremities. The limbs show greater variation than other parts. Normal range of skin temperatures according to Lewis, Pembrey, and Ipsen. Variations in health. Differences in the various localities of the body. Variation in the same locality under varying conditions.

Skin temperature in disease, i.e. Rheumatism, Vasomotor disorders, and other diseases. Skin temperature measurement is fast becoming a clinical test. Lewis's warm chamber, Brown's Vasomotor index, estimation of skin temperatures in protein fever or after administration of local, or spinal or general anaesthesia, have already established themselves in advanced medical practice.

Observation by the author at Vizagapatam. The first observations, made with an ordinary thermometer, are distinctly lower than those

recorded by the T.E. Couple. But comparative readings appear to be useful. The thermo-electric apparatus was arranged as described by Lewis. The condition of the environment, the state of the subjects, the localities of the body on which the observations were made are recorded. Charts to indicate the 24 areas studied. The averages, the highest and the lowest for each of the 24 points, are recorded both in a tabular form and in graphs. These results are compared with the conclusions of Foged. The average readings are higher than those of Foged and the graph of these readings almost resembles the plateaux, given by skin temperatures in protein fever, while the graph from Foged's readings presents a staircase appearance. In our readings, the trunk records the highest temperatures, while the readings from the head are lower. The readings from the upper limb are as high as those of the trunk and considerably above those of the upper limb in Foged's readings. The lower limb records a fall distalwards, though the fall is less marked than in Foged's data. Maximum temperatures recorded give a straight line like graph above 36°. Minimum readings present interesting differences in lowest temperatures reached and the range of variation particularly in the limbs. These are discussed.

Skin temperature, in relation to environment, in relation to body temperatures, dress, etc., is considered.

Standards for normal skin temperatures for South India are necessary for any further work in connection with variations in health and disease. Variations between skin temperatures in the tropical and temperate climate might explain the rarity of some and the frequency of other disorders in the tropics.

74. Some observations on the posterior limb of the marsupials.

B. M. LAL, Hyderabad, Deccan.

The paper deals with the dissection of the hind limb of a series of marsupials. The following results have been arrived at:—

1. The enlargement of the cuboid bone in the highly specialised foot of *Macropus* and *Dendrolagus* is due to the transmission of the body weight of the animal and not to the enlarged fourth metatarsal bone.

2. In the marsupials possessing a highly specialised foot *M. plantaris* is found functionally to take the place of *M. flexor digitorum brevis* when the latter muscle is wanting or deficient.

3. The statement of Leche and Dr. A. B. Appleton that *M. pyriiformis* is a neomorph in Eutheria and that a similar muscle resembling *M. pyriiformis* in Marsupialia is *M. caudofemoralis*, is substantiated.

4. *M. extensor hallucis longus* shifts its tendon of insertion to the second and third metatarsal bones, when the hallux is suppressed only in animals possessing a highly specialised foot.

5. The nerve supply of muscles in primitive mammals is less rigid.

6. In *Perameles* there is no loop of connection between the lumbar and the sacral plexuses.

7. *Perameles*, though a very primitive animal possesses a very stable posterior limb to some extent resembling the Eutherian animals in the restriction of the movement of the joints, with necessary bony modifications.

75. Meckel's Diverticulum.

HYDERALI KHAN, Patna.

Development. Embryonic area lies between the amnion and archenteron. The archenteron is included in the embryo and gives rise to the primitive gut. The remaining portion of the archenteron forms the yolk sac and this is connected to the primitive gut by the vitelline duct which passes through the umbilicus.

The vitelline duct usually atrophies and disappears about the 8th week. Persistence of vitelline duct gives rise to Meckel's diverticulum. It is situated on the antimesenteric border of the ileum about 3 feet from the ileocaecal valve.

Situation, Size and Forms.—1. Blind diverticulum quite free, sometimes adherent to umbilicus or adjoining viscera.

2. The diverticulum is connected to the umbilicus by a fibrous cord.

3. The vitelline duct is persistent at the umbilical end only.

4. The vitelline duct forms an umbilical adenoma.

5. Vitelline duct is persistent as a fistula.

History and Frequency.—Discovered by Meckel in 1812. Said to be present in 2% of cases. It is rarer in India.

Signs and Symptoms.—Normally no signs and symptoms unless inflammation or other complications set in such as:—

1. Intestinal obstruction—volvulus.

2. Intussusception.

3. Ulceration and perforation.

Treatment.—Excision.

76. The rôle of potential immunity in the production of tetanus antitoxin in horses.

B. B. SEN, J. NAHA, and S. C. BHATTACHARYYA, Calcutta.

Response of different horses to the same tetanus toxin (antigen) varies, and depends upon colour, race, age and specially upon the presence of natural immunity. We have found only 25 per cent. of all horses responding to the antigen in ordinary course. The natural antitoxin content of thirty-seven new horses, all Australian of almost the same age and colour, was determined, before starting immunisation. Twenty-six of them were found without detectable natural antitoxin. All the eleven found to contain natural immunity gave us, in ordinary course, 180 to 600 American units per c.c. The other twenty-six which did not show the presence of natural antitoxin were divided into two groups, of thirteen each. One group was immunised with the same antigen, three of this group gave only 100 American units per c.c. within three months during which immunisation was carried on. The rest of this lot ten failed to give even 20 American units per c.c. after three months. The other group of thirteen was first injected with two doses of toxin-antitoxin mixture, 3 days apart and kept at rest for two months, the same process of immunisation being followed afterwards. After a course of 2½ months, nine of this group of thirteen gave us 300 to 600 American units per c.c.; two, 180 American units per c.c. and two only gave us 50 American units per c.c.

Success in the production of immunity in these horses seems to be due to secondary response of the animals from the potential immunity developed in them.

77. Macro-topographic section of the thorax in diseases of chest organs.

D. N. BANERJEE, Calcutta.

The topographic relationship of the pathological changes in the thoracic organs to the neighbouring organs and the chest wall cannot be properly studied by the ordinary methods of performing post-mortem examinations by which the thoracic organs are removed from the thorax for detailed examination and preservation in the museum.

By following the technique of Walter Koch of Berlin several specimens of pneumothorax, empyema, cancer of the bronchus, etc. have been preserved in the museum of the Carmichael Medical College, a study of which will show the remarkable way how the topographic relation of the pathological condition and the domes of the diaphragm chest wall, displacement of the mediastinum, bands of adhesions preventing the collapse of the lung in pneumothorax, pressure effect of the carcinoma of the bronchus, etc. can be permanently preserved.

Section of Anthropology.

President :—P. MITRA, ESQ., M.A., PH.D., P.R.S.

Presidential Address.

RESEARCH LEADS IN ANTHROPOLOGY IN INDIA.

GENTLEMEN,

Allow me at the outset to thank you cordially for this honour of selecting me as president of this section this year. I am feeling all the more grateful for this recognition, though rather belated, of the Anthropological department of the Calcutta University which has been serving the cause of this science in its own humble way for the last ten years.

The provision for degree examination in Anthropology in M.A. and M.Sc. and also for the graduation course has popularised the subject and has brought into being that young band of earnest workers who are seen to be working at different centres. Specially the opportunities for submitting research thesis as part of work for the master's degree brought out important contributions in cultural anthropology and primitive ethnography such as the works of Nirmal Kumar Bose on the origin and significance of the Holi festival, of Sasanka Sarkar on the Malpaharias, and of Ramesh Chandra Ray on the Kharias. Research scholarships enabled Prabhas Chandra Bose, M.Sc., M.B., Anil Kumar Choudhury, M.Sc., M.B., and Nirmal Kumar Bose, M.Sc., to continue their useful work on Chota Nagpur tribes, and blood-groupings.

The Premchand Roychand research studentship has called forth good work in Anthropometry and Craniometry on the Brahmins of Bengal by Tarak Chandra Ray Chaudhuri, M.A., on the Hos of Kolhan by Dharendra Nath Majumdar, M.A., and on the craniometric data from Chota Nagpur by P. Bose, the latter two having spread the seeds to new centres such as Lucknow University and the Bose Institute from the Calcutta University. Of those whom we at one time or other reckoned as members of our staff we need only mention the late Rai Bahadur B. A. Gupte for work with Risley, Mr. Sarat Chandra Mitra for work on Indian folk-lore, Rao Bahadur L. K. A. Iyer for South Indian Ethnography, and last but not least Dr. B. S. Guha and Mr. K. P. Chattopadhyay to show how this department during the short period of its existence has been the starting or final refuge in some of the most brilliant careers in Anthropology in diverse fields in India. I do not want to tax your patience by a detailed list of work at present being conducted

by members of the staff, for a glance at the papers contributed would be sufficient to show the varied field now being tackled. Dr. A. Chatterjea has been working on the problems more affecting the welfare of the people and analysing about ten thousand data for finding the rate of growth amongst Bengali students. The ethnographic field work by Mr. T. C. Das in Manipur last year, thanks to the help offered by Mr. Higgins, brought out some new facts about dual organisation in Assam and this work with the generous promise of help with funds by Prof. Wissler from New York is hoped to be continued successfully. Thus with all its major preoccupation with teaching work the department has been carrying on research and we confidently hope that Behar which is a veritable museum of primitive tribes would soon open in the Patna University a centre for Anthropological studies, under the lead of the renowned Anthropologist of Ranchi.

Research leads from India which saw the starting of linguistic classification of mankind with the Asiatic Society of Bengal should be very many. Pater Schmidt, Sten Konow, and Grierson's work has shown how much more could be done even now and the Austro-Asiatic or Pre-Dravidian problem is justly again engaging the foremost attention of scholars. The Dravidian linguistic problem is still unsolved and the comparative study of Melanesian languages by Dravidian scholars seems to promise to open up new tracks. Similarly the experience gained by the study of the classification of the Amerindian languages would be very fruitful in dealing with the Tibeto-Burman languages and the remarkable linguistic affinities of some of these with languages as the Algonquin is well worth enquiring into.

In Social Anthropology it was Sir Henry Maine's Indian experience that could be said to have set the ball rolling with the patriarchal theory. Morgan's wonderful discovery of the value of terms of relationship was brought home to him by study as much of Hawaiian data as of the remarkable affinities of the Dravidian and the Senecan Indian system. The origin of exogamy is still shrouded in mystery but it is one of the fundamental problems of Hindu society where it has still sway. So Lowie's correlation of exogamy with the classificatory system of terminology, the Dakotan in America, and the Dravidian in India is of intense interest. Radcliffe-Brown has suggested that the Dravidian, Australian, and the Melanesian systems had forked out of the same common prototype. A detailed study of the primitive systems like that of the Dieri in Australia or of the Pentecost in Melanesia with the Birhors of Chota Nagpur and some of the primitive tribes as we came across last year such as the Old Kuki Aimols are yielding very promising results. The outstanding feature of the marital system of these areas would be, according to Rivers, a hypothetical gerontocracy which originated these conditions and much more

that peculiar grandfather-granddaughter marriage that brought it about. Now gerontocracy is a problem of whose traces in some parts of India there are certain indications. The system has further the custom of ranking alternate generations as eligible for marriage. This Type II marriage in Australia would be that with the mother's mother's brother's daughter's daughter. Now this would be an alternative of the eligibility of marriage with the mother's mother or mother's mother's brother's wife or alternatively the mother's mother's brother's granddaughter as another variant of the granddaughter marriage, of course all in a classificatory sense. Now the characteristic kinship terminology of this system would be to class the elder brother with grandfather and the elder sister with the granddaughter. Now this is exactly what is found in the eastern part of India where these terms are the same. There is a prevalent jocose relationship between the granddaughter and grandson and the grandfather and the grandmother respectively. There is also a ranking alternate generations as eligible for marriage rather than consecutive generations amongst exogamous groups in certain castes in Bengal. Thus it would be possible to start with some ground for investigating the existence of the grandfather-granddaughter marriage in a classificatory sense in some parts of eastern India at least. This would be the primitive stratum in India. Over it has been superposed perhaps that section of people which practised cross-cousin marriage in India. This is definitely associated with Dravidian whose kinship terminology has made the terms for mother's brother, father's sister's husband and father-in-law identical as in Tamil, and mother's brother's wife and the father's sister are both called by the same name and the mother's brother's son, the father's sister's son and the brother-in-law receive the same name. This cross-cousin marriage practising people are, according to Rivers, a later immigrant stratum in Melanesia. In Australia also we have the other type who practise the cross-cousin marriage. Thus these problems have to be studied in a wide field with geographical distribution and cultural dispersal over this wide area from India to the Pacific, and might have been brought about by the same causes—the migrations of new peoples or setting up of new culture standards. In any case we have the succession of two strata both in primitive India and the Pacific, the earlier practising grandfather-granddaughter marriage in the classificatory sense (the marriage with the mother's brother's widow peculiar to Melanesia being perhaps a feature of matriarchal societies), and the later practising cross-cousin marriage. Similarly, according to Morgan, the Hawaiian system would be antipodal to the Aryan system and Rivers has shown that the former far from being primitive is a result of later developments and it is interesting to find how close is the parallelism between

early developed Hindu culture in North India and Polynesia by (a) absence of sept exogamy in Hawaiian and possibly also in early Vedic society according to Karandiker; (b) the definite occurrence of brother-sister marriages (as amongst the chiefs of Hawaii) in Pali traditions in India for reasons that are advanced which show very highly developed theories of blood-purity and laws of inheritance which brought into vogue this system only amongst the chiefs; (c) privileged jocose relationship in later Hindu society between those who are punaluan relatives in Hawaiian terminology as also between brother's wives and sister's husbands; (d) absence of the term for mother's brother probably in the earliest Vedic stratum as in Polynesian society.

The stratigraphic study of culture in the line of the German school and mapping out of culture areas and definite distribution of traits of a culture complex is far more yielding of results in the fields of material culture. If the theory of Matthew of South Central Asia being the cradle of mankind be true and if since Miocene times there have been migrations of anthropoid and proto-man types from near the border of the Himalayas to the borders of the Pacific on the one hand and Africa on the other, India has very likely played a very prominent part in the distribution of early cultural traits if not of physical types. What we mean to say is that by the study of material cultural traits common to India, Africa, and the Pacific, we might arrive at those prototypes which are likely to be common and originated in a central home of dispersal. In physical anthropology as well mere working out the old Karl Pearson formula of racial correlations would but reveal several different strands and the branding of Mongoloid on some Alpine strains as by Risley is likely to be followed by similar blunders when one idea would reign supreme. On the other hand it is likely that some undifferentiated protomorphic varieties from which sprang the Negro of Africa on the one hand and the Negritos of the Pacific on the other might have been the direct ancestors of some of the darkest tribes of India like the Kaders who differ from the Negroes as much by the absence of the cinky hair as from the Negritos by being dolichocephalic instead of brachycephalic. The frizzly hair common to India and Melanesia has to be studied anew in detail and specially the hair of hybrid groups of the Negro, the Mongol, and the Caucasian.

Similarly the recent studies of Dr. Broom in South Africa are revealing the probable existence of a South African Australoid race who have left their mark on the physical features of the Koranna peoples and the Australoid problem in India cannot be studied in isolation from the data from Africa on the one hand and the Pacific on the other. The implements

from early pleistocene in South Africa and those from South India on the one hand and Tasmania on the other reveal striking similarities. Is it mere accident that these are made of quartzite and the predominant forms in these now separate regions are more or less the same in some marked contrast to the predominant European types? The rectangular *coup de poings* so characteristic of South India have just their match from South Africa on the one hand and the 'Tronattas' or aboriginal stone implements used by the Tasmanians on the other. Mr. Cammiade's studies have shown the possibility of the succession of pluvial periods and dry epochs in India to have followed similar lines as in Africa. Are we to take it that the similar stone implements are the results of similar environments in South India and Africa? But the climate of South Africa and Tasmania were entirely different from that of South India and is it that in the stone implements of these three areas we have the mute records of common descent of an original type of culture from a central area? The study of the stone implements is generally supplemented by an investigation of other primitive cultural traits for our knowledge of early man. Here the methods of American Cultural Anthropologists are of great help for the mapping out of traits generally shows a centre of origin or dispersal. Further the wider the distribution in space the greater the presumption in favour of greater antiquity of the trait concerned.

As a possible survival of the early stone age culture complex we could take up the boomerang—the famous throwing stick of the Australians. According to Graebner as shown in his classic study of the Melanesian bow-culture there were five stratifications of which the old Australian culture with the boomerang was the earliest followed by Totemistic culture and then a matriarchal dual organisation after which came the Melanesian bow-culture complex and still later the Polynesian culture. Now this boomerang culture-complex in Graebner's study is associated with the crudest shaped stone implements, the weather screen used as dwelling and crude sticks. This weapon is common to India, Africa, and Australia—a fact known since the days of Pitt-Rivers who has described in detail all the Australian, African, and Indian examples, whereas two varieties, the returning and the non-returning type, come from Australia, the returning type is not known from India. Though Lubbock had objected to the classification of Indian, Australian, and African boomerangs together for the return flight is known from Australian weapons only Pitt-Rivers was disposed to hold that this return-flight type was a special development in the Australian region. Thus the studies of Pitt-Rivers in the light of recent methods would make Australia the centre of

origin of the boomerang and though peripheral it spread from that area to the entire region of this culture. Or it is possible that the return-flight type was once known to India and has disappeared with the tradition remaining only of a type of arrow that returned to its owner as recorded in the *Mahābhārata*.

Similarly the study of the bow which occurs over such a wide area of the Pacific and Africa as well as India could be studied profitably along with arrow-release distributions. Kroeber's study of arrow-release distributions has shown that between India and Melanesia the eight recorded cases of tertiary arrow-release has become intertwined with both primary and mediterranean types of release in that area and the distribution shows a centering at least of the mediterranean release in India of the tertiary release in or near Indo-China and of the primary along the eastern of Pacific edge of the area.

The problem of the dispersal of such domesticated plants as the taro and the banana as well as of such domesticated animals as the fowl shows a centre of dispersal near central or eastern India from which they spread to the Pacific on the one hand and Africa on the other most probably in very early hoe-culture times preceding the introduction of regular agriculture. The South-East Asiatic origin of the hen has been recognised since the days of Darwin for in those regions only the combed chickens occur in a wild state. It spread thence from Persia to Greece and Europe on the one hand and the furthest east on the other. In Assam and Chota Nagpur the domestication of the fowl had become a necessity on account of the ritual use of eggs for divination purposes, as Lowie thinks in his 'Are We Civilised?' It is this function that led to the propagation at first of this useful animal. Similarly so far as the taro is concerned there is evidence, according to De Candolle, of the edible *Colocasia*s being transplanted from India to Egypt and the studies of Rivers in his essays collected in 'Psychology and Ethnology' show the probable centre of origin of the taro in the centre of India from which area it spread eastwards and westwards. Similarly, perfectly seed-bearing banana being only indigenous to India it is very likely that all the very widely distributed varieties of bananas and plantains were propagated by migrating man from the original single species of *Musa sapientum* in India as Kew Garden botanists hold.

Thus the comparative study of culture over intercontinental regions would likely reveal the important rôle of India as a primary or secondary centre of diffusion of cultures in several stages of her culture complex in the march of time. The first period would be in earliest stone ages when India was not only sharing the common type of quartzite palæoliths

with the eastern and western tracts but also perhaps the boomerang and possibly the simple type of fire-drill. Later came the bow and the musical bow complexes and Miss Roberts in the course of her study of Hawaiian Music has made a strong case for the original home of stringed musical instruments in India. In early Neolithic times the problems become more complex but some of the earliest types of the domesticated plants and animals might have spread along with the hoe or the spade. The reckoning of the year from the Pleiades rising has been well known in Polynesia and was the current mode in early Vedic times in India and also in Africa as Hirschberg has recently shown it was spread throughout the coasts of East Africa and also distributed over at least thirty-six tribes throughout Africa not excluding its occurrence in Old Egypt.

The simple type of rectangular habitations well known in the Polynesian area and very possibly the dominant North Indian form in Vedic times and also found in several regions of Africa might have as well got dispersed at this period.

The plough once thought to be developed from the hoe by Tylor and elaborately studied by Hahn who derived it from the hoe and the phallic symbol has recently been revised by Leser who in his masterly work divides the plough into two types, the four-sided plough and the plough where the rear side of the beam is curved (Pflug mit Krümel). The quadrilateral type is more widespread. The form of the share of this type shows how the spade forms so common in India since Neolithic times and the lunette spade celts in copper as from the Gungeria copper-finds would have been more likely to be in use as share. Still later the problem of the domestication of cattle is very important from the Indian standpoint. Associated also with this problem as perhaps of the same culture complex is that of the wheeled vehicle. The Indian cattle cart without the wheel occurs in the Manipur area as we found last year, and solid wheels are in use over a large part of India still, and wheeled vehicle toys of terracotta occur in Mohenjodaro. Each of these problems have to be taken separately and studied in detail, and later on the correlations have to be worked out with the help of distribution maps. A study of these simple things would be likely to recover for us the lost pages of the cultural progress of India in Neolithic and Chalcolithic times and would supplement the findings of the archæologists.

Finally, along with the philological, archæological, biometric, geographical, and cultural methods of the West, India has also to seek inspiration from her own culture patterns to be able to combine the methods and break into new paths. The philosophy of the Hindu Tattva of man has engaged the

attention of its subtlest thinkers and philosophers from the earliest times to the present day. To them the study of man does not only reveal the sequences of human activities in historical and prehistoric times but much more it does bring out the action, reaction, and interaction of energies from the highest states of consciousness or *Chit* to the lowest states of matter or *Jar* as they call. As pithily put by Satyasrayee the Hindu view-point would be this:—The side of the finer aspect of creation is *Chit* or Consciousness and that of the grosser is inert matter or *Jar*. The mass of living beings is the result of the interaction of the different types of *Chit* energy in *Jar*. Man is the result of the culminating interaction of the highest types of *Chit* in all types of *Jar*. It is a far cry yet from the India of the day when it would not merely echo the modern West but would try its own methods to interpret anew the laws of nature and the predominant culture-pattern of India would lead it to its time-old probing of all the secrets of creation through the introspection and scientific investigation of microcosmic man.

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Abstracts.

1. A new photographic apparatus for recording profiles of living persons.

P. C. MAHALANOBIS, Calcutta.

One great disadvantage of measurements on the living is the want of standardisation which renders the greater part of the data collected by different workers practically useless for comparison. In this new apparatus a profile photograph of the subject is taken with the help of a parallel beam of light. The results are practically free from appreciable personal errors. In one series of experiments six photographs of the same subject were taken by different observers at different times. The readings usually agreed within one per cent. and even the maximum difference did not exceed two per cent. The apparatus can be adjusted very quickly, and it will be possible to take from 20 to 30 photographs per hour.

At first great difficulty was experienced in arranging a correct registration of a fixed point of reference (which coincides approximately with the centre of the ear-hole in the present apparatus). This difficulty was overcome by Mr. Narendranath Sen, under whose supervision the instrument has been constructed, with the help of a precise optical device which leaves a very fine point trace on the paper.

2. History and morphology of Tibetan polyandry in Malabar.

A. AIYAPPAN, Madras.

(Communicated by R. Gopala Aiyar.)

Existence of two types of polyandry in the same geographical area; the Nayar type well known, but not the other. Rapid disappearance due to clash with exotic cultures. Travellers' records of T. Polyandry. Legendary accounts of its origin from manuscript sources. Kandyan polyandry in relation to the theory of the origin of the artisan classes from Ilam. The Tiyaṅs of Malabar originally patrilineal and polyandrous, but latterly becoming matrilineal. Ilavan marriage custom—their seven geographical divisions and thirty *Kiriyaṅs* (exogamous septs)—*Kiriyaṅ* affiliation through the mother. Consecration of and rules relating to connubial partnership. Age disparity among partners in the joint marriage. Peculiarities of the sororate and levirate of polyandrous tribes compared with those of others.

Discussion of the probable causes of T. polyandry in Malabar. Opinions of experts within the caste.

3. Adichanallur Bronze.

S. PARAMASIVAN, Madras.

(Communicated by R. Gopala Aiyar.)

Chemical analyses of bronze specimens from Adichanallur in the Madras Museum collections. Probable sources of the constituents of these bronzes are discussed and these suggest relationship with other countries.

4. Traces of Totemism in some tribes and castes of North-eastern India.

BHUPENDRANATH DATTA, Calcutta.

Traces of Totemism and Taboo are to be found amongst the Cacharis of Assam, the Santals, the Bauris, the Koras, the Khorias of the district of Bankura in Bengal. The Cacharis worship Monsha tree; the Santals claim the Sol and Pankal fishes and Betel-nuts as their ancestors and abstain from eating the same; the Kashya Bog (striped heron) is one of the gotras of the Bauris, and dog is a taboo to them; the Khorias have lamb for their gotra, and it is a taboo with them. The Koras have tortoise, duck, Sol fish, egg as their gotras, and these are taboo to them.

It seems that in original tribal stage these animals and trees have been the totems of these tribes and castes. But more they began to come under the influence of surrounding Hindu culture, more the totems began to lose their significance. In some cases the totems remained as objects of veneration, in the other they are remembered as ancestors, while in the third they remained as taboos.

It is evident that the testimonies of the names of the animal and tree ancestors of these peoples and the abstention from using the same, bear the traces of totemism and taboo in the process of their cultural evolution.

5. The Khasis.

TARAK CHANDRA ROY CHAUDHURI, Calcutta.

An anthropological study based on physical measurements and observations. Subjects measured 132. Measurements have been studied according to the modern principles, and biometrically analysed. The measurements taken are stature, head length, head height, facial length, facial breadth, bigonial diameter, nasal length and breadth, orbitonasal diameter and arc.

6. The Chirus of Manipur, their descent and social organisation.

TARAK CHANDRA DAS, Calcutta.

Linguistically a branch of the Old Kuki group, the Chirus are scattered over a few villages mainly on the banks of the Logtak Lake in Manipur. According to the orthodox account the tribe is divided into five exogamous clans each of which may marry in some definitely fixed clans. Both males and females of a particular clan may not select their spouses from one and the same clan. Descent is patrilineal and predominantly so for the males, but the females observe matriliney in certain respects, over and above their patrilineal filiation. Cross-cousin marriage of one type is allowed while the other is prohibited. There are indications of similarity with the Pentecost social organisation as found by Dr. Rivers in many respects.

7. Distribution of cephalic index in the districts of Bengal.

A. CHATTERJI, Calcutta.

From a study of large number of students from different districts in Bengal it was found that in Mymensingh there is a distinct dolichocephalic average of 75.2, a meso-brachycephalic average is found in the districts of Jessore, Faridpur, Khulna, and Hughly, with average over 80; the people of South-west Bengal are mesocephalic and give averages between 78 and 80. The people of East Bengal are on the whole dolicho-mesocephalic and give averages which are below 78. Dolichocephaly again reappears in the districts of Maldah and Rungpore.

8. A preliminary study of the rate of growth of Bengali students.

A. CHATTERJI, Calcutta.

Comparing the rate of growth of the Bengali student with that of other peoples it was found that in the average Bengali student, the growth is suddenly arrested at the age of sixteen and that throughout the growing period, the gain in body weight is proportionately less than the increase in height.

9. Preliminaries to the study of the racial problem in India by blood-grouping.

ANIL CHAUDHURI, Calcutta.

(Communicated by Dr. P. Mitra.)

Determination of racial factors by blood group method. System of classification as employed by different authors. Hirschfield's result is compared with the author's Bengali data. Frequencies also compared. Whether statistically significant or not is determined by Prof. Karl Pearson's formula. Existing racial controversies regarding the peoples of India. Co-relation of blood group methods with other anthropological methods.

10. Trade-guild basis of Indian caste system.

SATKARI MITRA, Calcutta.

(Communicated by Dr. P. Mitra.)

The Indian caste system did not rise out of the antagonism between the conquering Aryans and the conquered non-Aryans. Originally it began as a professional grouping which developed into trade-guild system. Each guild became a closed organisation of the members of a particular professional group with a certain deity as its patron. In this form of development there is a similarity with the guild systems of ancient and mediæval Europe. The Indian guilds had not then transformed into 'castes', they were then 'classes'. 'Classes' transformed themselves into 'castes' when commensality and connubium were interdicted. That was of very late growth. The status of a 'class' and its later representative 'caste' have been determined by class-struggle.

11. Aimal Kuki.

JYOTSNA KANTA BOSE, Calcutta.

(Communicated by Dr. P. Mitra.)

The Aimal Kukis are a branch of the old Kukis only 387 in number. They are studied in the village of Khma Aimal on the banks of the Logtak Lake.

They are brachycephalic, platyrrhine, of medium stature, with yellowish brown skin colour and oblique eyes, with traces of Mongolic fold.

They are divided into four endogamous divisions, each of which is again sub-divided into two exogamous subdivisions, viz. :—

(1) Chonghom	Khosir. Thirchung.
(2) Chaithu	Lumdin. Lusai.
(3) Lanu	Darkhumpu. Durnai.
(4) Chonghomlaita'	Darnu. Sambukpu.

Marriage is patrilocal and monogamous. An interesting type of dual organisation with a type of cross-cousin marriage is found among these people.

The Aimals have a kind of conception of the soul. They have a high god 'Pathion' who is the creator of the universe. Ancestor-worship and propitiation for the malevolent spirits of the dead are in vogue among these people. They have also a belief in after life.

12. Chothe Kuki.

RAMESH CHANDRA ROY, Calcutta.

(Communicated by Dr. P. Mitra.)

The Chothes are a branch of the old Kukis studied in the Chothe village near Visanpore in Manipur State.

The Chothes are of medium height with mongolic features and dark yellow skin colour.

The Chothes are divided into six exogamous clans, viz. Marim, Hiyang, Thao, Jurung, Piring and Makhang or Marimmakhong. A Chothe woman of one clan must marry into one or other of only three out of the five remaining clans. Marriage is patrilocal and monogamous with few cases of polygamy. The relationship system is classificatory and typical cross-cousin marriage is found in this society.

The Chothes bury their dead and they have a belief in after life. They have a kind of the conception of the soul. They worship various spirits and deities. Ancestor-worship prevails among them.

13. Cultural affinities between India and Africa.

JIBAN KRISHNA GAN, Calcutta.

(Communicated by Dr. P. Mitra.)

The investigation of several cultural traits common to India and Africa, such as quartzite palæoliths, boomerang, simple bow, cross-bow, loom, smelting of iron, conical and rectangular habitations, fire-drill, simple musical bow, canoe, floats; fishing traps; ornament, e.g. brass or copper rings; string games, e.g. saw I; saw V; knot I; knot II; peacock's foot; the hand; at jali; machhi jal; tooth and finger mutilations; sati rite; domesticated plants like banana, taro; lotus; domesticated animals like fowl and cattle, with distribution maps, has brought out several remarkable Indo-African cultural affinities. Several of these traits are common to Oceania and are peripheral in their distribution in relation to India. A rough chronological sequence has also been attempted.

14. A comparative study of the somatic characters of the peoples of Eastern India and Polynesia.

HARAN CHANDRA CHAKLADAR, Calcutta.

15. The somatic characters of the Uzbek and how are they related to the Turki speaking people of Chinese Turkistan.

B. S. GUHA, Calcutta.

A comparative study of the physical characters of the two groups based on the measurements taken by the author in 1929 in Chitral.

16. The significance of the Padmāsana or Lotus Seat in Indian Iconography.

A. K. MITRA, Calcutta.

(Communicated by Dr. B. S. Guha.)

Sanskrit and Pali texts and the theories of Dr. A. K. Coomaraswamy and of Mr. A. M. Hocart on the symbolism of the lotus seat are discussed : a comparative study of Indian and Egyptian Iconography.

17. The origin and distribution of the Car festival in India.

B. K. CHATTERJEE, Calcutta.

(Communicated by Dr. B. S. Guha.)

A survey is made of the present distribution of the Car festival in India among the Jains, Saivas, Vaisnavas, etc. The festival was popular also among the Buddhist of Ancient India. The origin of the institution is discussed from the standpoint of ancient texts.

18. Habitations of the Maitais.

S. J. SINGH, Imphal.

(Communicated by Dr. P. Mitra.)

Plan of a Maitai house showing elaborate arrangement for different sections of which the central one is the fire-place where a fire is always kept. The door is on the east or north generally and different places are assigned rigidly to different members of the family. The posts of the house have different names and some have a magical significance.

19. Marriage among the Ūrālis of Travancore.

L. A. KRISHNA IYER, Travancore.

The Ūrālis are a small jungle tribe found in the Peermade and Thodupuzha taluqs of Travancore. Marriage among them is by exchange of sisters. No man can have a wife unless he has a sister to give in exchange. Formerly an Ūrālī married as many wives as he had sisters. The result is that a number of young men remain unmarried. The scarcity of women is caused by the selfish action of old men. Cross-cousin marriage is in vogue. Polyandry seems to have died out.

The system of marriage by exchange of sisters is found among the Ullādans and the Malavādans of Travancore, and it co-exists with cross-cousin marriage.

20. The levirate and sororate in Travancore.

L. A. KRISHNA IYER, Travancore.

The custom of levirate has a world-wide distribution, while sororate is almost overlooked. The two customs are found complementary among

the Ūrālis, the Ullādans, and the Mannaus of Travancore, while levirate is alone practised by the Malaarayans and Kānikārs. It is interesting that the Malavēdāns practise neither levirate nor sororate. Dr. Frazer thinks that the two customs are traceable to a common source in a form of group marriage. Dr. Westernmark does not concur with this view.

21. A few interesting aspects of Orissan Ethnology.

S. C. ROY, Ranchi.

Section of Psychology.

President :—DR. GIRINDRASHEKHAR BOSE, D.Sc., M.B.

Presidential Address.

A NEW THEORY OF MENTAL LIFE.

FACT AND FANCY IN SCIENCE.

The body of knowledge we call Science is made up of facts and fancies. The facts constitute the observational data which provide the materials for the edifice of science, and fancy acts as the mortar which cements such materials and arranges them in certain patterns evolving a definite architecture. This fancy is the mother of theories which are so essential to the development of any science. The scientist takes care that his fancy is kept within proper limits otherwise it is likely to be more a hindrance than a help to him. Scientific fancy in its simplest form is inductive inference. When the inductive process is a little more complex and is meant to serve as an explanation for a group of facts it is called a theory. A theory is capable of being tested for its correctness by specially devised crucial experiments. The function of a theory is to explain certain groups of facts in a simple manner and nothing is postulated that is redundant. The philosopher, however, is not bound down by such considerations. He gives a freer scope to his imagination. The explanations that he gives, to solve the problem of ultimate reality for example, can neither be proved nor disproved in many instances. Such explanations receive the name of speculations.

The scientific man does not usually indulge in any speculation. His aim is to confine himself to theories only, and for this purpose he observes certain canons or principles as his guide.

Psychology concerns itself with the study of mental phenomena and tries to find out the laws that govern mental life and determine its evolution. For the proper understanding of the workings of the mind psychology has to formulate theories just like any other science. Psychological theories should be judged by the same criteria that govern scientific theories in general. For a person who is familiar with the psychological terrain it would be quite easy to evaluate the findings of this special science by means of the same criteria that hold good in the material sciences. A properly formulated psychological theory has the same validity as any physical theory.

MENTAL ENERGY.

Just as the physicist has to assume the existence of some form of physical energy to explain changes of state and of position of matter so a psychologist has to conceive mental energy to explain mental changes. Energy being a theoretical concept is never directly observable ; its existence can only be inferred by the change it produces either in the physical or in the mental sphere. With the introduction of the dynamical conception into psychology attention of workers was directed towards the study of mental phenomena, not as static events taken out of the context of mental life, but as active living processes.

The theory of the dynamic unconscious mind came into prominence in psychology as a result of the investigations of Freud.

As the new theory that I intend to discuss in this paper has developed out of work along Freudian lines among my mental patients, I shall first of all give here a very brief survey of the evolution of Freudian thought and the new conceptions that have been formulated to explain certain facts of mental life. This will serve the purpose of an introduction to my theory.

PSYCHO-ANALYSIS.

About the year 1880 there was an eminent physician practising in Vienna named Joseph Breuer, and Sigmund Freud who was then a young man was his assistant. Breuer had a young female patient who was a confirmed neurotic. This patient had been treated by most of the eminent physicians of Europe, but all to no effect. She told Breuer one day that if she could tell him all her troubles he might do something for her. Breuer, who was a very sympathetic physician, agreed to her proposal and the patient began to unburden herself. Breuer had no time to hear her story at one sitting, so he arranged to spend an hour daily with his patient. The patient's accounts proved to be sometimes very embarrassing as she gave many details of her private and family life, details which were entirely beyond the province of a medical man. Curiously enough, as the patient went on with her story her symptoms began to improve, till finally she was completely cured. Breuer communicated this wonderful cure to his colleague, and asked him to take up similar cases and treat them on identical lines. This experiment proved highly successful and soon several cures were reported by Freud. On analysing the mechanism of these cures, Freud noticed that the patients suffered from a sort of pent-up emotion connected with certain incidents in their past life, and when these pent-up emotions were discharged in recounting the past history, a relief for the symptoms

was obtained. It was sometimes found that the patient failed to bring up childhood memories in the ordinary waking state. Freud tried hypnotism to bring up such past experiences. There was a certain number of patients who could not be hypnotised, and Freud had to devise another method to bring out the forgotten impressions. This method has been called the Free Association Method. The patient is asked to lie in a comfortable position with closed eyes. The room is kept darkened and the patient is asked to relax all his critical faculty and to speak out everything that came up in the mind without considering whether such material was relevant or irrelevant, good or bad, logical or absurd, decent or indecent. Under these conditions it is found that the apparently unconnected thoughts produced by the patient are really connected together by a hidden and thoroughly relevant chain of associations which gives an indication of an aspect of the patient's mind which is not present in consciousness. Proceeding on these lines it was possible for Freud to unearth memories and experiences which had long remained beyond the range of consciousness. The evolution of the Free Association Method marks the beginning of psycho-analysis.

When he first began this work, Freud had no idea of the sort of material he could come across by digging into the unconscious. He was, therefore, quite surprised when he found that in all the cases that he had analysed, the hidden unconscious mental processes were of a sexual nature. It was supposed by Freud that as a result of social and environmental conditions aided by certain organic developmental factors early infantile sexual cravings got pushed back, or repressed as it was technically called, into the unconscious sphere of the mind. These cravings, however, did not die out, but after a period of latency broke out years later in modified form as neurotic symptoms.

Psycho-analysis has established the fact that so long as a mental content remains unconscious it tries to act in an autonomous way without reference to the conscious attitude of the personality, and forms a potent source of pathogenic mental disturbance owing to the conflict it sets up with the rest of the ego. Once it is brought up to the conscious level it yields to the forces of reason and loses its morbid character.

UNCONSCIOUS MENTAL CONTENTS.

The tendencies that are usually unearthed during psycho-analysis may be generally classified under certain groups, viz. trends belonging to the bi-sexual nature, e.g. the desire to possess the sexual characteristics of the opposite sex, desire in a male to bear a child, etc. homo-sexual wishes both active and passive, incest desires, narcissistic and auto-erotic wishes,

manifestations of the oral and anal libido, sadism, masochism, observationism, exhibitionism, desire for intra-uterine life, aggressive hatred towards parents mainly from sexual motives, fear of castration, fear of birth, unconscious sense of guilt associated with sex life and a punishing conscience, death wish directed towards self or others, etc. The unconscious tendencies enumerated here aim at fulfilment in diverse indirect ways, e.g. phantasies, dreams, symbolic activities, identification, projection, introjection, displacement, transference, slips of the tongue and pen, accidents, character traits, sublimated activities, physical and mental psycho-neurotic symptoms, crime, violent outbursts of temper, escapades, irrational behaviour, likes and dislikes, etc.

From what has been said before it would appear that different types of mental processes such as ideas, wishes, feelings, emotions, judgment, memory of past events, images, etc., go to form the contents of the unconscious mind.

Feelings, emotions, and wishes have all been credited with the power of controlling the behaviour or motor activity of the individual.

CATHEXIS.

In the early cases it was found that a pent-up emotion in the unconscious could produce various symptoms. A mere revival of the memory of the incident would not produce a cure. The emotion attached to it had to be lived over again or abreacted, as was technically called, before the disappearance of the symptoms. The essential constituent of the emotion with feeling as its central nucleus has been called the affect. On the analogy of an electrical charge it was assumed that the affect might invest an idea or an object with interest, feeling, significance and energy, and this charge might shift from one mental entity to another. This charge has received the name of cathexis. It is the cathexis that makes a love object significant. The introduction of the theory of cathexis has enabled the psycho-analyst to explain many facts of psycho-pathology and normal love in a satisfactory manner.

Unconscious wishes mainly connected with the sexual sphere attempt fulfilment in diverse ways. These mechanisms are particularly noticeable in dreams and psycho-neurotic symptoms. It is assumed that the unconscious wish is subjected to certain forces which prevent its appearance in the conscious plane. The ego is supposed to exercise the censoring influence on all unconscious dynamic mental contents.

MENTAL MECHANISMS.

Symbols are extremely common in dreams. As the significance of symbols remains unconscious they are utilised in weaving phantasies that would elude the censor. A dream,

although highly significant to the subject, may come into consciousness without any feeling tone attached to it. In some dreams the affect is displaced to some indifferent idea. Several objects in a dream may stand for the different attributes of one significant object and conversely a single dream image may represent in a condensed form many different images. All these mechanisms serve to hide the real meaning of the underlying unconscious wishes which seek fulfilment in dreams or psycho-neurotic symptoms. An unconscious wish sometimes effects a compromise with the repressing force, and in expressing itself in consciousness shows the characteristics of both. Unconscious wishes partake of the nature of physical forces. They can come into conflict with one another and effect a compromise, they may change their forms, undergo summation and condensation, and the investing charge or cathexis might shift from one point of attachment to another.

IDENTIFICATION.

The phenomenon of identification requires elaboration as it forms one of the fundamental mechanisms of mental life. Freud describes the 'so-called identifications as insufficiently known processes and hard to describe'. He says 'identification is the earliest expression of an emotional tie with another person'. It moulds the ego after an ideal. 'Identification is ambivalent from the very first; it can turn into an expression of tenderness as easily as into a wish for someone's removal.' According to Freud the unconscious hostile feeling of the child towards the father which is so often unearthed during psycho-analysis is traceable to this mechanism. The difference between object choice in love and identification may be described as the difference between 'like to have' and 'like to be'. The object 'choice' or 'like to have' may regress to identification or 'like to be' under the stress of circumstances. A classical example of this is to be found in the Vaishnav literature. Krishna's consort Radha believes herself to be Krishna himself when she finds it impossible to get him.

PROJECTION.

The mental mechanism known as projection should next claim our attention. The term projection is used in psycho-analysis in a restricted sense. It is generally meant to denote the attribution of one's own unconscious desires and motives to another person. This mechanism is most in evidence in that form of insanity called paranoia. In this disease the patient harbours hostile feelings towards other individuals in his unconscious mind. This leads to a delusion of persecution by others.

Projection like identification appears to be a fundamental mechanism of mental life.

INTROJECTION.

Introjection is the reverse of projection. This term has been introduced into psycho-analysis by Ferenczi. It is used to denote the process by which ideas of external objects or characteristics of other individuals are incorporated with the ego. Freud describes introjection as secondary to identification. When a love object is renounced or lost it is sometimes introjected inside the ego by the mechanism of identification as in the case of Radha. Sympathy, empathy, and other similar processes are all derivatives of identification.

THE EGO.

Having discussed the interpretations of the important fundamental mechanisms of mental life, using the term in its widest sense to include the unconscious also, we may turn our attention to the problem of the ego.

The unconscious region of the mind from which instinctive strivings arise Freud calls 'the id'. The term 'id' or 'it' denotes its impersonal nature. According to Freud 'the conduct through life of what we call our ego is essentially passive, and we are "lived" by unknown and uncontrollable forces. The mind of an individual is an unknown and unconscious id upon whose surface rests the ego.' The ego has been evolved from the id as an adaptation to meet the environment.

THE ID.

The ego is the agency that is entrusted with the testing of reality. The activities of the ego are, therefore, mainly guided by the demands of reality, or, as Freud expresses it, the reality principle guides the ego. The strivings of the id, on the other hand, are not subject to the exigencies of the external world. In the id pleasure principle reigns supreme. Thus there is a sort of opposition between the ego and the id, and this opposition primarily provides the motive force for repression. Besides the testing of reality, the ego is thus seen to be entrusted with another important function, viz. that of keeping the undesirable elements in the id under control.

THE SUPER-EGO.

In the early years of childhood, strivings of a libidinous nature directed towards both the parents arise in the mind and tend to seek fulfilment in action. The ego exerts a censorship on these wishes which are then pushed into the unconscious

region of the mind. As the cathexes of wishes of this type are very strong they elude the censor and come out in consciousness in many indirect ways. The repression is seldom perfect and most of these indirect manifestations are invested with anxiety symptoms. To cope with this unpleasant and undesirable state of affairs the ego has recourse to the two mechanisms previously mentioned. The parents who are the love objects are introjected inside the ego a part of which is thus invested with parental characteristics. The parental authority, in being introjected, assumes the character of an incontestable ideal which the ego unconsciously adopts. The ego-ideal or the super-ego thus formed helps the ego in its work of repression. The super-ego acts as the unnoticed inner prototype of the external social institution. Its orders to the ego come in the shape of both prohibitions and positive commands such as 'you must not do this' and 'you must do that'. In this respect the super-ego retains the character of a stern father towards his little child. In certain diseases, e.g. obsessional psycho-neurosis and melancholia the super-ego behaves in a particularly severe manner towards the ego, and the pangs of conscience of such patients can only be explained on the supposition of the presence of an unconscious idea of guilt.

We may now sum up the characteristics of the Freudian ego and the super-ego. The ego forms the superficial layer of the mental life and is the entity that comes into contact with the external world. It is partly conscious and partly unconscious. It is the appraiser of external reality and acting with its ally, the super-ego, it serves as a critic, a supervisor, a mentor, and a censor of our mental life. The super-ego is a later construction than the ego. It is sometimes friendly to the ego and sometimes hostile to it. It goes to form the unconscious component of the ego. It is in direct communication with the id and may also help the id in its activities. The super-ego is the nucleus of the conscience in the normal individual, and forms the unconscious basis of the higher nature of man. According to Freud it contains the germ from which all religions have evolved.

SEE-SAW MECHANISM.

I have given an extremely brief and inadequate account of mental life and the interpretations that have been proposed to explain the different types of psychic phenomena. The new theory of mental life that I propose to delineate here is the outcome of my psycho-analytical work during the past twenty-two years. In the course of my analyses I found that the symptoms connected with a repressed element in the unconscious would not disappear even when it had been made conscious by analysis and the patient had accepted the truth of the interpretation. Apparently all the resistances had not been

overcome. Under such circumstances a curious thing was seen to happen. The nature of the symptoms changed and the free associations of the patient and his phantasies and dreams showed the presence of an unconscious element of the type opposite to that originally unearthed. The original repressed material had been apparently replaced by its opposite. The symptoms were, therefore, traceable to opposite groups of forces. As the analysis proceeded the opposite repressed tendency came into the conscious mind and the primary repressed element, which had been made conscious before, lost its significance or sank back into the unconscious level. When this was brought to consciousness again, its opposite, in its turn, disappeared from view. The see-saw mechanism, as I have termed it, would go on for some time with striking regularity, but with a gradually decreasing intensity of the opposite tendencies and an increasing frequency of oscillation till a time came when both the elements would be conscious and acknowledged by the patient; it was only then that the symptoms disappeared.

The see-saw mechanism has either escaped the notice of most psycho-analytic observers or sufficient importance has not been paid to it. I shall, therefore, go into it a little more deeply and illustrate it by examples from an actual case record.

ILLUSTRATIVE CASE.

The patient is an educated young Mahomedan gentleman of a sensitive and sentimental temperament. During the last communal riot in Calcutta he developed an obsessive fear of being stabbed from behind. The fear tormented him even when the riots had ceased, and he was absolutely safe in his own house. Owing to these attacks of senseless anxiety the patient was incapacitated for any serious and sustained work. The first days of analysis revealed the different situations in which the fear appeared and the precautionary measures adopted by the patient to guard himself against it. The patient knew that the fear was baseless. As the analysis proceeded he brought up phantasies of a retaliatory type. He imagined himself exceedingly strong although he would complain of his physical weakness in his sober moments. He indulged in all sorts of imaginary aggressive activities directed against roughs and hooligans. This gradually led to the revival of the memory of school-boy fights in his childhood when he used to play the tyrant with younger boys. Homo-sexual scenes of the active type began to appear in his associations, and it was then seen that in the unconscious mind the patient had equated ordinary fight with sexual assault. He felt a good deal of shame in narrating these incidents. At this time the interpretations of his dreams showed the presence of passive homo-sexual traits in the unconscious. When asked about them he expressed his

abhorrence, and stoutly denied his ever having played the passive part. The shame and disgust felt also for the active attitude gradually vanished, and following this the patient had an open passive homo-sexual dream. Immediately afterwards the retaliatory aggressive phantasies disappeared, and he quite suddenly remembered one day a very early incident in which a servant had forced him to play the passive part. Gradually other passive incidents of his school days came up in his mind and he recalled on one occasion at least his willing participation in the act. The revival of memory of passive incidents was not now attended with pain. Curiously enough the dreams of this period showed an active attitude with a distinct pleasurable colouring. When this was made conscious it dominated the patient's phantasy and the passive rôle became again unpleasant in consciousness. Analysis of the symptoms made him appreciate his unconscious desire for the passive situation, and gradually the fear of being stabbed disappeared from the mind, and the patient could bring up at will and enjoy in imagination both the passive and active attitudes. There were other complicating factors in the case but I have purposely left them out and have confined myself to only one set of opposing factors to show clearly the alternation of his active and passive attitudes.

In reviewing the case we notice that the fear of being stabbed represented in the patient's unconscious a wish to be passively treated in a homo-sexual situation. The fear replaced the wish in the conscious symbolic manifestation. In the present instance the wish is the primary element and the fear a repression product. Similarly the shame, disgust, and abhorrence noticed towards the passive and active homo-sexual situations are all traceable to repression. The unpleasant feeling-tone attached to the active and passive situations, like fear, seemed also to be a repression product. It has been held by Freud and others that shame, disgust, etc. are the factors which bring about repression, whereas according to the explanation given here they were not the causes but were the results of repression of some originally pleasurable wish situations; the pleasant affect connected with a wish was changed into an unpleasant one by repression.

TENTATIVE HYPOTHESES.

The facts of this case could be explained by certain tentative hypotheses. We may assume that opposing tendencies or more strictly mutually contradictory pairs of wishes, e.g. active and passive homo-sexual desires in the case cited, exist in our mind. Under certain circumstances, not determined for the present, the wishes seek fulfilment simultaneously. As the action attitudes corresponding to these wishes are mutually contradictory they cannot have simultaneous satisfaction. The mutual

opposition may result in the banishment of both these wishes from the sphere of consciousness, e.g. in the first stage of treatment when both active and passive homo-sexual desires were outside the sphere of the patient's awareness. The complete inhibition of action, due to mutual opposition of the wishes, corresponds to the unconscious phase of the wishes. One of the wishes may overcome the other and may come to occupy the conscious field, its opposite being forced to remain unconscious, e.g. the appearance of active homo-sexuality in consciousness and evidence of passive homo-sexuality in dreams of that period in the illustrative case. As the struggle is not thereby ended the conscious wish is rendered more or less impotent and can find partial satisfaction only in imperfect acts and phantasies; the evidence of the struggle is also to be found in the change of the original pleasant feeling-tone into an unpleasant one; the association of shame and disgust with the memory of early active homo-sexual situations, in the case cited, is to be traced to this factor. After the conscious wish has had a partial satisfaction in phantasies or other activities its strength suffers diminution, and then the rôles are reversed; the opposite wish comes to occupy the conscious mind pushing the other into the unconscious, e.g. the appearance of passive homo-sexuality in the patient's mind first in a dream and then in memories of early life. Sometimes the opposing wish remains in consciousness divested of its significance; an effort to restore the significance is attended with painful emotions; e.g. the return of unpleasantness in connection with the passive rôle when the active homo-sexual situation was pleasurably revived. After the see-saw mechanism has been in operation for some time all unpleasantness in connection with the opposition is replaced by pleasantness, and both the wishes are invested with their original pleasant affect. Both are then conscious in the fullest sense, and can have complete independent satisfaction at different times; e.g. the revival of pleasant memories both of the active and of the passive situations by the patient. We may then conclude that of two opposing types of wishes one acts as the repressor and the other becomes repressed. The opposition in the example cited here was between activity and passivity.

RETALIATION.

I shall now take up certain other facts of normal and abnormal mental life that would serve to confirm the tentative hypotheses put forward by me. Let us consider the phenomenon of retaliation in normal life. For the purpose of our analysis I shall take a simple case of retaliation. A strikes B: B retaliates by striking back A. In retaliating, B behaves exactly like A. Retaliation follows the old Mosaic law,—eye for eye, tooth for tooth. It will be seen that in the primary situation

B is compelled to play the passive rôle whereas in retaliation he takes the active part. The reversal of the subject-object relationship gives us the clue to the mechanism of retaliation.

So long as B is not able to retaliate he feels an unpleasant tension which is replaced by pleasure during the execution of the retaliatory act. To what is this unpleasant tension due? What is the source of pleasure in retaliation? Why does the retaliatory act follow the Mosaic law? These are some of the pertinent questions that demand an answer. It will not do to say that all this is self-evident and requires no explanation. It is easily seen that the satisfaction that accrues from the retaliatory act is attached to the fulfilment of the retaliatory wish. We, therefore, find that in being struck, B develops a wish which is exactly identical in all respects with the wish felt by A in striking, except for the subject-object relationship which is seen to be reversed. The genesis of this wish could only be explained by the supposition that it was a reaction which was equal and opposite to the original action. This explanation, which is allied to the Newtonian law, is more physical than psychological. If we assume that in B there existed the pair of opposite wishes, to strike and be struck, even before A came into the field we can find an easy solution to the problem. These opposite wishes under the ordinary conditions of life would mutually inhibit each other and would not obtrude themselves on B's consciousness. There would be unpleasantness in the act of giving a blow and receiving it. In receiving the blow from A, the unconscious wish to be struck was fulfilled, and the opposite wish, now freed from its restraint, clamoured for satisfaction, and appeared in the conscious mind. So long as it was not fulfilled the unpleasant tension continued to trouble B. If we now look at the problem from A's standpoint we shall find that most probably A felt himself in the position of an injured person when he struck B, so that the wish to strike developed, after a real or imaginary satisfaction of the opposite passive wish, in a manner exactly similar to that in the case of B. If there was no real or imaginary grievance on the part of A, and if he had been compelled to play the aggressive rôle owing to circumstances over which he had no voluntary control the opposite wish to be struck being now free, would come in his conscious mind as a fear of assault from B, i.e. he would develop a dread of retribution. This factor is at the root of what we have described before as the punishing conscience which represents both a wish and a threat.

In all retaliatory acts the pangs of conscience are absent. The inhibitions imposed by conscience have a striking resemblance to the restrictions of actions brought about by repression. Moral considerations do not primarily trouble us where eating, walking, and similar activities are concerned. Repression also follows a similar law. We do not come across repression

phenomenon in the sphere of hunger which, like sex, is a powerful instinct, and which is similarly liable to meet with obstructions in life.

The theory of the opposite wish, as I have described it in connection with the phenomenon of retaliation, will serve to explain all the peculiarities of the conscience both in normal and in abnormal individuals. If we assume that pairs of opposite wishes appropriate to different ethical situations are in continuous conflict in every one of us we can easily explain the inhibitions of conscience and their disappearance in special cases when one or the other of the pair finds satisfaction.

IMITATION AND IDENTITY.

The phenomenon of imitation next demands our attention. Imitation has an important bearing on the development of the child's ego. The child learns many things by imitation. The imitative tendency is supposed by many to be an instinct and no attempt has been made to analyse it. It is closely allied to retaliation on the one hand and to identification on the other. Its manifestations are best studied in the case of the child. In being kissed the child learns to kiss. This behaviour is very similar to retaliation and can be explained on the basis of the same theory. The desires 'to kiss' and 'be kissed' remain in mutual conflict in the child at this stage so that in being kissed, the child returns the kiss, and in actively kissing its mother the child expects a kiss from her. It would be justifiable to suppose that the passive situation, to which the child is subjected, gradually leads to the development of the passive wish which in turn gives rise to the active one. The active wish may be supposed to remain latent at first and as the passive wish grows in strength by repeated submissions to the appropriate situation, the active one also correspondingly becomes stronger till at last it outgrows its latency and becomes a fully developed wish. It is at this stage that the satisfaction of the passive wish leads to the release of its active counterpart resulting in an imitative behaviour. The active wish may, therefore, be considered to arise as a sort of reaction to the passive wish. In imitation there is an identity of action with the original situation. Imitation may, therefore, be called action-identity as distinguished from ego-identity to be explained presently. Action-identity is to be seen when the child repeats a word it hears. In listening to the word the child plays the passive rôle and in repeating it he imitates the original action. Action-identity gradually leads to the development of ego-identity. In imitating the mother, the child not only acts like her but also feels like her. This is the stage at which the child plays the mother with its dolls. The opposition between the original situation and the action-identity phase is one be-

tween activity and passivity whereas the opposition in the ego-identity phase is one between the subject and the object ; it is more thorough than the first form of opposition. It gives us the clue to the mechanism of introjection in which the love object is incorporated with the ego. The theory of the opposite wish would thus explain the genesis of the super-ego and the mode of its action.

The field of identification is much wider than would appear at first sight. An object, with its special features, is apprehended in a wish situation by the mechanism of identification. It would seem that in all relations of the subject with inanimate objects, the opposite counterpart of the conscious wish seldom or never goes beyond the stage of latency ; there is no possibility of direct fulfilment of such a wish in real life ; but identification always remains unhindered, or we might say that the object becomes significant only to the extent to which identification is successful. It will be seen that in full and complete identification lies the solution of the conflict in repression, because it is only by this means that opposite types of wishes can have simultaneous satisfaction. There is no other way to avoid the struggle.

MODESTY.

Sexual modesty affords yet another illustration of the conflict of opposite wishes in normal life. I think that the manifestations of modesty are best explained by the theory of the opposite wish. The fear and repulsion, which are important constituents of modesty along with pleasure and attraction, are traceable to the conflict between opposite wishes coming up at the same time. A modest woman tries to hide her personal charms, specially those connected with sex. This is due to the inhibition of the trait known as exhibitionism. The desire to be seen is its chief characteristic. It is opposed by observationism or the peeping tendency. When a girl is confronted in some delicate situation the exhibitionistic tendency is satisfied involuntarily : under such circumstances, in her efforts to hide her face with her hands, she feels a tendency to look between the fingers. This may be explained by the supposition that the opposite peeping tendency becomes free as a result of the satisfaction of its counterpart. The female dress hides the charms but at the same time it imparts ~~secondary sexual organs such as the~~ These opposite traits are traceable to opposite wishes. Modesty, therefore, is a ~~menon.~~

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other similar findings constitute the empirical foundation on which the theory rests. From the standpoint of determinism, the development of any particular wish is the result of environmental conditions. The environment produces the perceptions which are forms of latent wishes. In submitting to the influences coming from external objects it develops corresponding wishes of the passive type. The passive phase of the organism is directly responsible for bringing about an active reaction. The active reaction phase likewise develops the active wish to modify the environment. Since actions and reactions are simultaneously in operation and since they are opposite in nature, it may be said that in all cases wishes having opposite qualities develop in pairs. One of the pair may remain latent as in potential reactions. For a wish to appear in consciousness it is necessary that its action phase should not be unduly obstructed, i.e. it must have opportunities for actual satisfaction so that its channel of discharge might develop adequately. If the organism is repeatedly forced to submit to impressions coming from outside, and at the same time its reactive phase is prevented from finding an outlet in action, the passive wish develops and gains in intensity while *pari passu* the corresponding active wish also develops; at first it is latent but with the increasing intensity of the passive wish, the active one also increases in strength, and strives for fulfilment; but as its channel for discharge, unlike that of the passive wish, has not developed adequately it sets up a tension within the system and ultimately comes into conflict with the passive wish. If the environment now changes and becomes favourable for the satisfaction of the active wish, still owing to imperfect development of its channel for discharge it cannot be relieved in action. The result is an inhibition of both the passive and the active wishes. This is how repression arises.

The theory of opposite wish would easily explain the genesis of the super-ego; the super-ego represents the opposite counterparts of the sexual cravings for the parents; it is itself a product of repression. Identification and introjection, which give birth to the super-ego, are traceable to the same source as repression phenomena as I have already explained. The energy of the super-ego is derived from the group of wishes that are the opposite counterparts of the oedipus tendencies, this is why it comes into conflict with the Freudian ego on the oedipus tendencies on the other. The theory explains all the facts of repression. The conception of the super-ego is not correct as it brings the manifestations of the unconscious into line, and represses the sexual tendencies and reactions and represses that is to be the supposi-

tion of the presence of an opposite wish. The theoretical ego with its opposite tendencies, as posited by me, will enable us to dispense with the three anomalous entities, namely, the Freudian ego, the super-ego, and the id, without sacrificing any of the advantage of the tripartite conception of the personality.

HYPNOSIS, SLEEP, AND DEATH.

The periodicity of sleep can be satisfactorily accounted for by the theory of opposite wish. During the waking state our activities are characterised by tendencies to mould the environment; the active desires are prominent, and they find satisfaction in action. This leads to a gradually increasing tension of the passive wishes till at the end of the day the rôles are reversed and the individual resigns himself in a passive way to the environment. The alternations of the manic and the depressive phases in certain psychoses may be similarly explained. If we push the theory to the speculative limit we may say that the activities of life must necessarily be followed by the passivity of death. Death is an extreme form of surrender to the environment. In hypnosis the subject surrenders to the hypnotist, in sleep he submits himself passively to a restricted environment, and in death he yields completely to the forces of the external world.

AMBIVALENCE.

In the mental life of perverts we come across certain opposite tendencies which regularly occur in pairs. The more important of these are sadism and masochism, observationism and peeping tendency, masculinity and femininity using the terms in their restricted sexual sense, and active and passive homosexuality. One of the pair in every case is active and the other passive. In psycho-neurotics also and even in normal persons the presence of these opposite tendencies forming pairs in close association with each other can always be demonstrated; one only of the tendencies in the pair is usually dominant in consciousness at a time. Many different theories have been advanced to account for this peculiarity of mental life. In my opinion no other theory except that of opposite wish will satisfactorily explain ambivalence as this phenomenon has been called. Ambivalence is one of the clearest forms of expression of opposite wishes occurring in pairs and is a strong proof of the correctness of the theory.

FREUD'S EXPLANATION OF AMBIVALENCE.

Freud in his paper on 'Instincts and their vicissitudes' mentions the different changes that an instinct might undergo under different circumstances. The reversal of an instinct into its opposite may be resolved into two different processes;

a change from active to passive and a reversal of the content. The first is best seen in the change of sadism into masochism and of peeping tendency into exhibitionism. The reversal of content is seen in the change of love into hate. The turning round of an instinct upon the subject is illustrated in melancholia where masochism is actually sadism turned round upon the subject's own ego. In 'reversal' the aim of the instinct is changed, whereas in 'turning round' the object is changed to self while the aim remains constant. The processes of 'reversal' and of 'turning round' are, according to Freud, independent of repression. Freud advances the theory that an instinct is built up by a successive welding of active and passive elements, and it is this that gives it the character of ambivalence. Regarding the antithesis of love and hate Freud would trace love to sexual instincts and hate to ego-instincts.

It will be seen that in his theory of instincts Freud has taken up a more biological than a psychological view of mental life. In a psychological theory of instinct the ego must be given a place quite distinct from its object; it is the subjective ego that feels the instinctive urge towards object other than itself; in passive situations although the object plays the active rôle it is the ego that is primarily affected. So far as the ego is concerned masochism and sadism are quite distinct and opposite tendencies. It is from the biological point of view alone that the two instincts are supposed to be identical in their nature; to an outside observer, who is indifferent to both the subject and the object, it is the action that is important and to him the manifestations of sadism and masochism are identical; in both the situations one organism is seen to inflict cruelty upon another; to the biologist all organisms are alike and there is no need to distinguish between the subject and the object; it is the action alone that counts. Freud's assertions that an instinct might turn round upon the self and that in narcissism the self can play the rôle of both the subject and the object at the same time, are traceable to the same biological attitude.

OPPOSITE WISH AND AMBIVALENCE.

The opposition of love and hate is satisfactorily explained by considering love as primary and hate as a repression phenomenon. The problems of reversal and of turning round of instincts will be satisfactorily solved if we study the relation between identification and projection and the mechanism of imitation, retaliation, and similar phenomena. Let us consider the attitudes of the ego in the different phases of a normal wish situation. The ego in experiencing a wish splits up into a subjective and an objective half. At certain times the ego looks at the world from the standpoint of the object of its wish; the object then may assume the characteristics of a secondary ego. The primary ego in placing itself in the position of the

secondary one feels all the strivings that a willing and reciprocating individual may experience in behaving as the object in the primary wish situation ; for example, when the primary ego feels the desire to kiss a person it invests the objective secondary ego with the desire to be kissed ; needless to say that the real object may not feel any such desire. The secondary ego, therefore, has all the characteristics of a reciprocating sentient person looking at the situation from the standpoint of the object ; it may be said that the sentient secondary ego also splits up into a subjective and an objective half. The primary ego can look at a wish situation from any of the four points in the wish circuit, and can feel four different attitudes corresponding to these points. Let us consider the hypothetical case of a person A who feels the desire to be struck by another person B. Such a situation is a prototype of the original passive situation characteristic of early child life. In the primary subjective attitude which dominates consciousness under usual conditions, A feels the desire to be struck by B ; in the secondary subjective attitude A feels that B has the desire to strike him ; in the secondary objective attitude A thinks that B feels that B is going to be struck by A ; and lastly in the primary objective attitude A feels that he has the desire to strike B. All the phases in the wish situation except the first are unconscious. They may appear in consciousness when repression is at work affecting the first phase. The first and the fourth phases represent the pair of opposite wishes. In the second or the secondary subjective phase the primary ego feels the strivings of the object ; this is empathy or ego-identity. In complete identification the ego appreciates both the second and the third phases. The third or the secondary objective phase, when it becomes conscious, represents what is known as a paranoid projection. This will be apparent if we take an active wish as an example. The primary active desire on the part of A to strike B is transformed in this phase into the expression B wants to strike A, which is a typical projection symptom. The fourth phase represents action-identity ; in being struck, A feels the desire to strike back ; this is the mechanism of retaliation and imitative action. The explanations that I have given here of identification, projection, imitation, etc. will bring into line all these manifestations of normal and abnormal mental life. Identification, projection, reversal, 'turning round,' etc. have been supposed to be primary activities of the ego defying further analysis. I have shown that they are all traceable to the operations of the opposite wish.

CONCLUSION.

The theory synthesises a large number of existing individual conceptions into a unitary whole. It does away with

the multiplicity of formulations, and brings many facts of abnormal life into line with the normal. It departs from the usually accepted psycho-analytical theories at several important points. In the first place it holds that wishes alone provide the motive force of our activities. Emotions and feelings, apart from their wish elements, are not to be held as incitors of actions. Perceptions are to be looked upon as latent wishes. It is neither pain nor pleasure, but it is the principle of unity that guides our wish. All wishes are efforts at bringing about a psychological unification of the subject and the object. Pleasure is more primary than pain. Pleasure is expressed in love and other pleasant emotional states ; pain in hate, anger, fear, and similar reactions. All painful affects have their origin in repression. The same opposite wish is responsible for repression as well as for the appreciation of reality according as it is hindered or free.

The theory gives us practical suggestions to bring up children in such a way as to prevent repression from interfering with their normal mental development. A knowledge of the theory will help the analyst to predict the nature of the unconscious material that is going to arise in consciousness at any particular stage of the treatment. It will facilitate the removal of repression and bring about quicker adjustments. In my papers on the 'Genesis of Homo-sexuality' and the 'Genesis and Adjustment of the Œdipus Wish' (*Proceedings of the Indian Psycho-analytical Society*, February, 1926, and September, 1928) I have shown the application of the theory to the solution of complicated and special psycho-analytical problems. It has enabled me to find a new technique of psycho-analysis (vide *Proceedings, Indian Psycho-analytical Society*, August, 1930). This technique when applied to suitable cases considerably shortens the period of treatment. I venture to submit that the theory of opposite wish throws new light on the mysterious ways of the human mind.

Section of Psychology.

Abstracts.

1. What is the basis of special ability ?

OWEN BERKELEY HILL, Ranchi.

The author discusses the conative and emotional factors which he believes led him to succeed or to fail completely in his attempt to learn, in the course of his life, fifteen foreign languages. He contrasts the attitude adopted towards the question of ability and disability by psychoanalysts on the one hand and experimental psychologists on the other. He makes a plea for greater co-operation between these two schools of psychology.

2. Physiological and experimental psychology of the Hindus.

M. N. BANERJI, Calcutta.

The Physical and Physiological basis of mental life. The study of Physical and Physiological principles of Psychology from the Upanishads. The systems of Philosophies. The Mahabharata. The Gita and Medical Literature.

3. An analysis of the first-attempt tracing time in Mirror-drawing.

S. S. JALOTA, Calcutta.

This paper reports on the *first-attempt* Mirror-drawing by 120 persons (53 females and 67 males) in the Mental Hygiene Section of the Calcutta Health Exhibitions, 1931 and 1932.

The individuals are divisible into four types according to the total time of Mirror-drawing. An attempt at their interpretation is based on the introspective reports of 8 students of the Department of Experimental Psychology, University of Calcutta. It is asserted that these *types* are made up of distinct combinations of several well- or ill-developed elementary behaviour responses, which are ultimately responsible for the time taken.

It also corroborates the earlier finding that females are superior in mirror-drawing.

4. Physical interpretation of psychic phenomena.

M. S. ALAM, Cuttack.

Some interesting 'psychic' observations by the author are described. These investigations prove the existence and reality of psychic forces. A physical theory of psychic action is suggested. It is assumed that thought is propagated in space by wave motion. If the frequency of the waves of thought of a particular person is the same as that of our waves when the latter arrive to him, he is thrown into 'resonance' and has thus a conscious glimpse of our thoughts and actions. Even if the 'receiving' person is not in the 'resonant' or 'sensitive' state, he may be affected to some extent by 'forced oscillations' produced in him by the waves arriving to him from the 'transmitting' person.

Further investigations are being carried on to determine the conditions favourable to the production of 'psychic resonance'.

5. Relation between timidity and modesty.

M. S. ALAM, Cuttack.

Timidity is shown to be the outcome of habitual modesty and bashfulness. The popular idea of modesty is a misconception. Modesty is synonymous with timidity. The extremely modest man is the timid man. Ideas and thoughts, which only glimmer in the minds of timid persons for an instant, are used with greater advantage by bolder persons. If we just ponder over the various aspects of our daily lives, we will find innumerable examples of failures brought about by a too rigid conception of modesty. Modesty is an impetus to timidity, which is a negation of the three principal attributes of success in life: confidence, optimism, and boldness.

An appeal is made to relax the rigidity of our firm belief in modesty as a virtue.

6. A theory of the function of emotions.

J. PRASAD, Patna.

Unsatisfactory state of the psychology of emotion. A brief reference to the views of McDougall, Rivers, Dewey, Droyer, and James. Cannon's emergency theory. Difficulties of these theories.

The typical characteristics of emotion, a stirred up state, and the situations arousing it are away from the ordinary and disturbing. The connection between a conative tendency and emotional excitement. Stout, McDougall, and Shand on this point. Obstruction of an impulse and emotional excitement. Rivers, Dewey, and Droyer on this point. A theory of the function of emotions as consisting in the reinforcing or energizing of conative tendencies. The nature of emotional situations, and endocrine secretion in support of the theory. Illustrations. Reconciliation between McDougall's theory and the conflict theory.

7. The induction of emotional states in laboratory experiments.

M. N. SAMANTA, Calcutta.

The methods extant in laboratories, to induce emotional states, are the application of smell, pleasant or unpleasant, a tickle or a prick. Sometimes, though rarely, simple tones are used. These, however, do not produce the desired effect. Other methods that can be conveniently used are (a) show of pictures, (b) chosen words or passages read out to the subject, (c) presentations of musical notes, (d) application of different tastes, etc. An attempt is made in this paper at a solution, which of these methods is the best to bring about the desired emotional state.

8. The general information of Bengali graduates.

A. K. DATTA, Dacca.

The Admission Test of the Teachers' College, Dacca, includes one set of questions on 'General Information'. These questions are selected (in a certain determined proportion) to measure the candidates' general knowledge in respect of events of the day, common scientific knowledge such as all should possess, social and æsthetic interests, literary and musical interests, etc. Two hundred and fifty to three hundred candidates take the test every year. The answers to these questions thus throw important sidelights on the amount of general information possessed by Bengali graduates.

This paper describes and summarises the answers covering five years, 1928-32. It also makes a statistical study of the results (particularly in the case of the candidates admitted into the College) in order to

ascertain the value of such a test on general information in picking up suitable candidates for the College.

9. A comparison of different statistical measures of intelligence based on a Group Test in Bengali.

P. C. MAHALANOBIS, Calcutta.

Over 1,200 school children in Bengal were examined some time ago by a Group Test of Intelligence in the Bengali language. A careful statistical comparison has been made between the different measures of intelligence by studying the actual frequency distributions. Most of the measures give rise to highly skew distributions. The deviation of the individual score from the mean score for the corresponding age divided by the graduated standard deviation (which may be called the Standard Measure) gives a practically normal distribution, and possesses great statistical advantages.

10. A new theory of sense-perception.

J. K. SARKAR, Muzaffarpore.

Sense-perception is the act of the inhibiting process of the mind.

Different views of sense-perception presuppose the different forms of inhibition.

There are five orders of inhibition, of which depression and repression are important. Depression rules consciousness, whereas repression governs the unconscious.

Release or removal of inhibition makes the introspective analysis of sense-perception possible.

Release or freedom of perceptual thought from the control of its materials and release of the latter from the control of the former are the psychological facts worth notice and evidenced by artistic thinking.

In fine, the proper study of normal sense-perception leads us on to the conception of the unconscious.

11. Working of an unconscious wish in the creation of plastic art.

RANGIN HALDAR, Patna.

Some of the Indian sculptures have been studied in the light of psycho-analysis. The *Lingam*, *Sadyojātā*, *Arddhanārīśvara*, *Mahisāsūramardini* and other images represent the various aspects of the Oedipus Situation. Head offering to the mother goddess in the southern sculptures represents castration complex, an important factor in the Oedipus Wish.

12. Aesthetic preference.

S. C. MITRA and S. K. BOSE, Calcutta.

Fechner's experimental aesthetics. Other experiments on Form and Colour preference. Their incompleteness. Some new experiments carried out in the Calcutta laboratory. Limitation of the experiments to the preference of Forms. Experiments with geometrical figures and especially designed forms. Suggestion of a new theory.

13. A new anaesthetic phenomenon.

GIRINDRASHEKHAR BOSE and S. K. BOSE, Calcutta.

Certain investigations have been carried out to ascertain the conditions under which special forms of tactual anaesthesia and analgesia

are produced. In presenting two stimuli, one more extensive and intense than the other, it was found that under certain conditions the milder stimulus was not apprehended even when its threshold value was much above the normal. A psychological interpretation of this phenomenon has been suggested and its bearing on practical life discussed.

14. Study on a condition of recognition.

S. C. SINHA and S. K. BOSE, Calcutta.

Pictures and diagrams have been exhibited as a whole and then cut parts have been shown to ascertain what amount of the total is necessary for recognition. Using the same materials three sets of experiments have been done with three groups of subjects—undergraduates, children from 6 to 11, and Garos (natives of the Garo Hill region).

15. Analysis of action consciousness.

S. K. BOSE, Calcutta.

The writer, who participated as subject in a long series of experiments in R.T. and Weight-Lifting, examines in the light of his own introspectional data the Titchenerian view of correspondence and non-correspondence of the three phases of action consciousness to the three periods in reaction experiments, and finds that the second phase differs in some respects from the mid-period.

16. Development of form perception in indirect vision.

H. MAITI, Calcutta.

It is well known that the perception of form in peripheral vision is imperfect. The matter is complex. As we proceed from the extreme periphery to the fobia the form perception passes through certain characteristic changes. The present paper describes these changes and makes an attempt to explain the peculiarities of form perception in peripheral vision. Incidentally the bearing of the problem on the general theory of perception is indicated.

17. Speed in mental work in relation to intelligence and scholastic success.

SARADINDU BOSE and H. MAITI, Calcutta.

A group of school students was given continuous mental work, both in the earlier and the later parts of school period for a number of days. Individual differences (1) in the increase of speed due to practice involved in work over consecutive days as well as (2) in the decrease of speed due to fatigue for prolonged work at a single sitting have been noted. A battery of Intelligence Tests was applied to the group and correlation between intelligence score and examination results on the one side and speed in mental work on the other were calculated.

18. Emotion, verbal images and speech.

M. N. BANERJI, Calcutta.

Formation of, and rôle played by, verbal images and emotions in the development of speech and intelligence. The vocabulary of a male child aged 22 months.

19. The conquest of senility by Steinach and Voronoff methods with demonstration of cases.

J. E. DHUNJIBHOY, Ranchi.

20. Visual perception of geometrical figure—Indirect vision.

M. GANGULI, Calcutta.

This paper is supplementary to the one published in the *Indian Journal of Psychology*, 1928, with this difference that it refers to the indirect vision.

Series of experiments were conducted with a view to determine the threshold, i.e. the omission that passes unperceived when a geometrical figure is not seen directly.

The distortions which the figure undergoes and the characteristics which accompany the perceptions have been mentioned incidentally.

21. Further studies on the effect of surrounding surface on the temporal phase of negative after-images.

H. MAITI and M. SAMANTA, Calcutta.

22. Child Psychology—Play Instinct.

S. GHOSE, Mayurbhanj.

General Discussions.

Sections of Botany and Zoology.

I. THE NECESSITY OF A MARINE BIOLOGICAL STATION IN INDIA.

The desirability of establishing a Marine Biological Station in India was emphasised at a joint session of the Botany and Zoology sections of the Indian Science Congress recently held at Patna on Wednesday, 4th January, 1933, at 2-30 P.M., under the Presidentship of Prof. Gopala Aiyer. A large number of members took part in the discussion.

In opening the proceedings the Chairman (PROF. GOPALA AIYER) said that a considerable amount of interest had been created by the proposal made in the *Current Science* about the inauguration of a Marine Biological Station in India. He called upon Col. Sewell to open the discussion.

COL. SEWELL in opening the discussion referred to the great gap which would be filled by the establishment of such a station. Huge sums of money were, in his opinion, spent annually on the expansion of agricultural schemes but he felt strongly that the sea which provided sustenance to a considerable number of people in the country was yet left entirely untapped. He sounded a note of caution and observed that in setting up such a station people ought not to be swayed by economic considerations alone which were secondary and subservient to the primary scientific and educational aspects of the project.

The establishment of such a station at Karachi had been mooted in the past, but owing to financial stringency the scheme seemed to have been indefinitely shelved. Nor was there any prospect of the proposal being brought to fruition now in view of the embarrassing financial situation in India. He favoured the location of the station in Bombay on account of its central position, and also because the citizens of Bombay would be able to make a fairly large financial contribution towards its establishment.

DR. SETNA of Bombay strongly supported the idea of establishing the Marine Biological Station at Bombay. Such stations existed in practically all the important countries of the West, and he felt that there was a great need for a station like this in India.

He further observed that the teaching of biology in India was somewhat defective, as preserved materials instead of living animals were mostly used for the teaching purposes. Hence our graduates lacked a knowledge of the biology of living animals.

Dr. Kemp had suggested the Andaman Islands as a suitable site for establishing a Marine Biological Station, but he thought that such a station should be located in close proximity to the principal marine routes and also near big fish markets. Since Krusadi and Andaman Islands were far out of the way, they were not suitable for this purpose. Bombay on the other hand was more centrally situated. This city was a centre of commercial life not only of India but also of Asia. A small admission fee to the station would be a source of revenue from the floating population of Bombay.

He also thought that utilitarian motives should not be the primary consideration in this connection. Bombay possessed good spots where this station could be located. The actual site could be selected later on. Modest beginnings could be made with a few tables, but the whole scheme would cost at least 80,000 to a lakh of rupees. Money was therefore the main problem. Owing to the present financial stringency not much support

can be expected from the Government at present, as the development of agriculture in the country was occupying their entire attention.

He said that he had approached private individuals and prominent citizens of Bombay, who had promised to give financial support to this scheme. He suggested that the authorities of the Science Congress should sanction a certain sum of money which would act as a nucleus of public subscription. He thought that various universities in India would also contribute handsomely towards this project.

The views of Dr. Setna were to a large extent endorsed by Dr. Das from Hyderabad-Deccan, who favoured Bombay as a site for the projected station. Dr. Das felt that Bombay was easily accessible to a large number of universities in the mofussil. He said that it was of vital importance that students of zoology should familiarise themselves with the habits of living marine organisms, in the knowledge of which they reveal striking deficiencies at present. Habits of living aquatic forms which are not so well known at present should be studied.

He observed that departments of fisheries should be run on scientific lines. The Marine Biological Station should make collections of marine animals and plants and sell these to educational institutions.

Dr. S. K. MUKERJI of the Lucknow University supported Dr. Setna's plea for locating the station in Bombay. As an ecologist, he said that Bombay was conspicuous in possessing varied types of environments, such as rocky and sandy shores and therefore the sea round about Bombay should be rich in ecologically divergent marine types. He felt that the time for passing fervent resolutions on paper had gone and they should now seize the present opportunity of setting up a Marine Biological Station in Bombay with modest beginnings. A combined committee of botanists and zoologists should be appointed by this joint session to work out a practicable scheme and suggest means and ways of giving effect to this scheme. For this purpose funds were urgently required. He thought that it would not be difficult to raise money, as the committee would seek the co-operation of various universities in India and the moral and financial support of the local and central Governments. He urged the delegates to support the choice of Bombay for the establishment of this station.

Dr. S. L. GHOSE of Lahore fervently supported Dr. Mukerji's idea of forming a committee and suggested that this committee should also be entrusted with the task of selecting a site.

Prof. R. H. DASTUR of Bombay said that a small beginning should be made. The committee should formulate the various problems which the station would tackle, but suggested that these problems should be placed before the public who will then be willing to give funds.

Prof. AWATI of Bombay in advancing Bombay's scheme said it possessed various types of environments, such as rocky and sandy shores.

Prof. Gopala Aiyer in winding up the discussion said that he had no objection to any particular place; Bombay or Madras would be equally good to him.

Dr. S. L. Ghose of Lahore then moved that a committee of five biologists be appointed by this joint session of Botany and Zoology sections of the Indian Science Congress to go into the question of establishing a Marine Biological Station in India.

Dr. B. K. Das of Hyderabad-Deccan seconded this resolution, which was carried by a large majority of members present.

The following five persons were elected as members to this committee :—

- (1) Dr. S. B. Setna of Bombay (*Convener*).
- (2) Prof. Gopala Aiyer of Madras.
- (3) Prof. George Mathai of Lahore.
- (4) Prof. R. H. Dastur of Bombay.
- (5) Dr. S. K. Mukerji of Lucknow.

After a hearty vote of thanks to the chair the meeting came to a close.

Sections of Agriculture, Chemistry, and Botany.

II. SYMPOSIUM ON 'VIRUS DISEASES OF PLANTS'.

A joint session of the Sections of Agriculture, Chemistry, and Botany was held on Thursday, 5th January, 1933, at 10 A.M., to discuss the problems in connection with 'Virus Diseases of Plants'. The following papers were presented followed by a discussion in which many members took part:—

I. SYMPTOMS.

1. Morphological aspect of virus diseases of plants.

M. SREENIVASAYA, Bangalore.

* Virus diseases of plants are so called because they have not till now been traced to any living factor, such as bacteria, fungi, protozoa, etc.; but they have been known to be caused by agents which pass through bacteria-proof filters. Of the various symptoms exhibited by virus affected plants, chlorosis of the diseased parts is the most prominent. Necrosis of the diseased tissues is not quite common. Virus diseases are considered to be systemic in so far as they are closely associated with growth and development producing characteristic symptoms round the growing points. The symptoms of disease are generally visible in the young leaves and tender shoots. Proliferation of the top, a poor development of the root system characterise many of the virus diseases: they sometimes affect the reproductive function of plants.

2. Cytological aspect.

M. J. NARASIMHAN, Bangalore.

During recent years investigations on the cytology of plants affected by virus have shown that certain changes occur in the virus-affected cells. (i) The chloroplasts in the diseased cells have been found to undergo disintegration, and in some cases have been reported to be loaded with starch, as in potato leaf roll and spike disease of Sandal. (ii) In the case of the potato leaf roll, the phloem cells have been found to suffer from necrosis, involving the collapse of the cell walls, and affecting the function of the sieve-tubes. Phloem necrosis has been observed only in very few cases. (iii) The claims of some investigators that they have detected flagellate organisms in the tissue of the affected plants, have not been confirmed by other investigators. (iv) Cytoplasmic inclusions associated with animal virus diseases, such as rabies, Fowl-pox, etc. which have been regarded to be of diagnostic value, have been observed in some of the plants affected by virus. The nature of these inclusions is discussed, illustrating them with reference to the inclusions found associated with the spike disease of Sandal, a serious virus disease prevalent in South India, especially in Mysore. The analogy of the inclusions found in Sandal spike, with the Bollinger bodies of Fowl-pox, in regard to staining reactions is pointed out.

II. TRANSMISSION.

3. The rôle of insects as vectors of virus diseases in plants.

T. V. SUBRAMANIAM, Bangalore.

It has been definitely established that insects play a very important part in the transmission and dissemination of virus diseases of plants.

The biological study of the subject has received considerable attention in foreign countries from numerous workers so that at the present day we have on record about 50 plants belonging to 27 Families—some of them being of very great economic importance like Sugarcane, Potato, Tobacco, etc.—known to be subject to virus attack of which many have been found to be transmitted by insect agency.

Among the insects noted as transmitting virus diseases in plants, insects with suctorial mouth-parts have been found to be more concerned than those with biting mouth-parts. Among the former, the Family Aphididae occupy the foremost rank as vectors of virus diseases with 27 to their credit.

A number of salient facts, viz. the incubation period; period passed by the virus principle in the insect vector; presence of the inclusion body in the insect vectors; inheritance of the transmitting power by the insect vectors; length of time necessary for the insects to feed before they are capable of transmitting a disease; production of different symptoms when a virus is transmitted by insects and needle inoculation, etc.

Very little work has been done in India, excepting the work of Uppal showing the close association of the mosaic of Capsicum (Chillies) and Thrips. Study of Sandal Spike Disease, a very serious disease in South India, the virus nature of which being definitely established now, has been taken up by the Agricultural Department, Mysore, and the Sandal fauna of the spiked and healthy areas has been worked out. Attempts to find out the insect vector or vectors of the disease by suctorial insects have not been a success as yet. The work is being pushed on intensively and the problem tackled from all points of view.

4. Artificial transmission of virus diseases.

M. SREENIVASAYA, Bangalore.

The experimental transmission of virus diseases is achieved in many ways which depend upon the nature and virulence of the causative entity. Mosaics are highly infective and are therefore readily transmissible to healthy plants.

Tissue transplantation and sap injection are the two well-known methods employed for the artificial transmission of virus diseases. A knowledge of the infectivity and susceptibility of tissues is useful in effecting successful transmissions and often suggests possible modes of natural disease dissemination.

Sap injections have not been successful in inducing diseases like Peach Yellows and Sandal Spike. In these cases, tissue transplantation of some type is the only successful method. Organic fusion of the diseased tissue with the operated stock in the early stages is essential to the success of the experiment. The infective agent, in these cases, has not so far been isolated free from the living tissues of the host.

5. Entomological investigations on the spike disease of Sandal.

C. DOVER, Dehra Dun.

The transmissibility of the spike disease of sandal was first established by Coleman in 1917, who also suggested that it was caused by a non-filterable virus which was probably spread by insects. Coleman's work led to some entomological work by Hearsey and other officers of the Madras Forest Department, but it was not until 1930, when workers at the Indian Institute of Science had confirmed and extended Coleman's studies, that serious entomological work commenced.

The entomological work briefly outlined here was initiated by Dr. C. F. C. Beeson, Forest Entomologist, Forest Research Institute, at the

instance of the Madras Forest Department and the Indian Institute of Science, and continues with the co-operation of these institutions. The first stage of the enquiry was a survey of the insect fauna of sandal and associated plants, along with such ecological and bionomic work as was felt to be necessary for the experimental and later stages of the investigation.

The survey, which was along roughly quantitative lines, was conducted at localities in the North Salem and Vellore districts of the Madras Presidency and in Coorg, and occupied more than two years. Some fifteen lakhs of specimens were obtained, the sorting, determination and analysis of which is now nearing completion. These collections have provided information on the species actually associated with sandal and on their seasonal and relative abundance which, by correlation with other information, has enabled us to select a list of probable and possible vectors for experimental investigation. It should be added that the general importance of the survey has not gone unrecognised and that arrangements have been made, with the generous assistance of some fifty specialists, for the publication of a series of taxonomic papers, which will be concluded with an analytical study. An introductory survey of the problem has also been published (*Indian Forest Records*, xvii, part 1, 1932). It is hoped that the entomological enquiry will not only result in a definite advance in our knowledge of the spike disease of sandal, but also form a unique contribution to South Indian entomology.

The species selected for experimental investigation belong mainly to the Homoptera, the Jassids *Petaloccephala uniformis*, *Moonia variabilis*, *Bythoscopus indicus*, and *Acropona walkeri*, and Aphids, Psyllids and Fulgorids being regarded as particularly important. Other suctorial insects (Heteroptera, Thysanoptera) are included in the list of possible vectors, as are certain mandibulate insects, such as weevils (species of *Sympiezomias*, *Dereodus*, and *Myloccrus*), Lycids (*Lycostomus praestus*), and various Chrysomelids and grasshoppers. The life-histories of most of the selected species have been studied by Messrs. N. C. Chatterjee and M. Appanna, and detailed papers are now in course of preparation. Mr. Chatterjee who was in charge of the field work for two years has also collected a mass of valuable bionomic information, notably on the food plants of sandal insects.

Experimental work has been in progress for some time, but only reached a stage that could be called scientific with the provision, early in 1932, of a well-equipped insectary at Bangalore by the authorities of the Indian Institute of Science. At this insectary experimental work takes three main forms, the principle in all cases being that specimens of an insect species which have fed for the required time on a spiked plant would transmit the disease, assuming that they are the vectors, when transferred to a healthy plant. The sandal plants used for the experiments are grown with hosts that are regarded as reducing resistance to spike disease. In the first experiment, a large outdoor cage containing some two hundred healthy and spiked plants has been utilised as a reservoir for sandal insects, daily collections by the field staff being released into it. We have therefore reproduced in this cage a controlled, miniature sandal forest with an intensified and varied insect fauna, thus covering the possibility of transmission by insects that are not included among our selected species. This reservoir also serves the purpose of providing insects for other experiments.

Fresh infections in this cage would establish the theory that spike disease is transmitted by insects, but the species or group of species responsible would remain to be determined. To save time we are therefore conducting experiments with groups of insect species, thus narrowing down the process of elimination. The deductions from the survey work are also being extensively tested by means of experiments with individual species. In short, the object of the experimental investigations is to test every generally accepted theory of insect transmission, and to furnish

definite evidence on the rôle of insects in the spread of spike. Every fresh clue or suggestion is accordingly investigated immediately and subjected to experimental test, thus requiring the continuation of field and bionomic work.

An elaboration of the outline presented here will be found in the publications of the Forest Research Institute and the reports issued by the working committee on Sandal Spike investigations. Entomological investigations on sandal also form part of the duties of the Entomological Department of the Agricultural Department of Mysore, but their efforts, like ours, have not so far yielded any positive results.

III. PROPERTIES.

6. Theories regarding the nature of Virus diseases.

B. B. MUNDKUR, Pusa.

Theories regarding the nature of virus diseases are reviewed as follows :—

Bacterial theory was first suggested by Meyer and supported by Iwanowski. Bonequet revived the theory when he found nitrate reducing bacteria in beets affected by curly top. It has been accepted by Dickson who found evidence in support and Bewley has introduced the concept that bacteriophage and virus of plants may be alike.

Enzymatic theory was enunciated by Woods and Koning who found excessive oxidase activity in diseased leaves which interfered with the translocation of starch and elaboration of food for the growing tissues. The theory was supported by Heintzel and Chapman but Freiberg thought that not an oxidase but a specific mosaic enzyme was responsible for the disease.

Several investigators beginning with Matz have reported upon microscopic bodies with a definite shape and structure in diseased tissue. Some consider them as degenerate products of affected cell metabolism, others as 'x' bodies, some put them in the uncertain protozoa, the Chlamydozoa and Rickettsia, and few as protozoa and mycetozoa.

Beijerinck's theory that it is a filterable living fluid is supported by Dugger who suggests that the virus is corpuscular, long process of grinding which kills bacteria does not inactivate it, it is adsorbed by carbon and some plant juices, and that it is as inert and inactive as a colloidal particle apart from the cell but within the cell it reproduces abundantly. The size relation of a bacterial plant pathogen to a virus particle is as 1,000,000 to 26. Vinson and Petre have freed it of nearly 99 per cent. of associated solids and consider that it may be a peculiar chemical. But owing to the need of passage through an insect before becoming infective in a few cases and on other grounds, it is still considered as a living fluid, several properties of which are known.

7. Cultivation of the virus principle *in vitro*.

S. V. DESAI, Pusa.

The investigations were started to see whether the virus of the mosaic disease acted as bacteriophage on organisms present on the host plant and in soil. The dissolution of the organisms was not perceptible.

Next the tissues of the diseased plants were placed on special agar surface after sterilising the outsides of the tissues with mercuric chloride. A peculiar kind of growth of a pleomorphic organism was found to occur on long incubation. The growth was dotted with transparent plaque-like areas. The tissues of healthy plants remained sterile under the same circumstances. The organisms were cultured on agar and in broth but the characteristic of plaque-like formation of transparent areas persisted. Various attempts were made to free the organisms of the supposed associated bacteriophage without success.

Small quantity of the virus was inoculated in the suspension of the organisms and incubated. After incubating for five days the suspension was filtered through sterile filter candle and the small amount of the filtrate added to a fresh suspension of the young organisms. Several passages of the virus were thus carried out to see if the virus multiplied during the serial transfers.

Inoculation experiments for the reproduction of the disease were carried out with the suspension of these serial transfers. The inoculum used contained the virus principle diluted to $1:10^{16}$, $1:10^{30}$ and $1:10^{44}$, far outside the limits of infective dilutions. The inoculated plants reproduced the original symptoms of the disease showing thereby that the virus principle multiplied in vitro either with or at the expense of the organisms.

The same type of organisms were re-isolated from the plants in which the disease was produced artificially.

8. Some observations on Bacteria in relation to virus diseases.

N. V. JOSHI, Pusa.

When Iwanowski first made the discovery of the causal agent of tobacco mosaic in the filtrate of the juice of diseased tobacco plants after its passage through porcelain filters, this agent was considered to be a 'filterable virus', something different from the known pathogens including bacteria.

Beijerinck confirming the results of Iwanowski on the filterability of the virus assumed the causal agent to exist as a 'contagium vivum fluidum'.

Since then many plant diseases have been determined to be caused by viruses. According to the ideas about bacterial life existing at the time of the virus discovery and a long time afterwards, the failure to get uniformly successful inoculations from organisms isolated from plants affected with some of the more common forms of virus diseases was regarded as proof that the diseases were not of bacterial origin and this has deterred a systematic investigation of the diseases from the bacteriological side.

However, ideas about the life cycle and morphology of bacteria under different cultural conditions have changed and are changing. Not only have many bacteriologists established that bacteria pass through a life cycle and under different conditions may exist in different visible forms, but recently Hauduroy in 1929 and Hadley in 1931 by adopting new methods have been able to show a filterable stage in the life cycle development of bacteria and Swezy and Severin (1930) have shown indications of the existence of filterable forms of bacteria in the beet root affected with curly top disease and the leafhopper that transmits the curly top of beets.

In the bacteriological laboratory at Pusa we have studied the mosaic diseases of several plant hosts (1931 and 1932) and have succeeded in isolating cultures of bacteria from different plants affected with mosaic. Inoculation experiments with some of these cultures have been successful in reproducing all the symptoms of the virus diseases. In studying the cultures of these bacteria, we tried to follow the life cycle of the organisms. After filtering the cultures through L3 candles sometimes a growth could be observed and the slides made from this growth on staining showed different sized organisms from the smallest granules to the usually larger sized organisms. Critics who doubt the cyclogeny of bacteria would naturally consider this as a proof not of the different stages of bacteria but of faulty technique in inexperienced hands and consider the granules to be particles of stained organic matter. However, as one of the organisms, we were examining, happened to be a flagellated bacterium, we tried to stain its growth in the filtered broth.

On examining the slides, we found the small granules bearing flagella in the same way as the larger sized bacteria. This is perhaps the first time that such an observation is recorded. The fact that the growth in the filtrate when inoculated on agar gives the same kind of growth as the original culture shows that there is filterable stage in the bacteria we have studied. The flagellated nature of the granules may not convince some critics that they represent bacterial forms but at least it will make them pause before they totally reject the theory about the filterable stage in bacterial life. An idea about the size of the flagellated granules can be got by examining the slides or comparing the flagellated granules and the flagellated organisms observed in the microphotographs of equal magnification.

In the end I may point out that as the things stand there is very little difference between visible bacteria and the viruses. The dividing line between them is one of size only.

Now if the existence of filterable forms of bacteria is assumed on the evidence as presented in recent bacteriological publications cited above and in the present paper, then the possibility of the viruses being filterable forms of bacteria naturally presents itself. I suggest that it is necessary to examine this possibility more thoroughly as one of the possible methods of arriving at a solution of this perplexing problem of virus diseases, because the pressing need for knowledge regarding the actual nature of the viruses is admitted by all those who are interested in the investigation of virus diseases.

IV. PHYSIOLOGICAL STUDIES.

9. Biochemical studies.

B. T. NARAYANAN, Mysore.

It is well known that plants affected with virus diseases exhibit characteristic physical changes with equally characteristic chemical changes which are often cited as causing these diseases. The most prominent of these chemical changes is the disturbance in their carbohydrate content, particularly an accumulation of starch. This accumulation is known to occur in both 'Mosaic' and 'stunting' diseases. It has been established to occur in the case of the spike disease of sandal which is characterised by the shortening of its leaves which are often chlorotic. The consequences of this carbohydrate disturbance are described and discussed.

An unbalanced nitrogen relation between a healthy and diseased tissue has been found to exist in most mosaic diseases and several 'stunting' diseases. The nitrogen relation of healthy and diseased sandal is described.

The influence of the availability and distribution of certain inorganic nutrients on the progress of virus diseases with special reference to sandal spike are considered and discussed.

10. Physiological studies on the virus diseases of plants.

A. V. VARADARAJA IYENGAR, Bangalore.

In view of the fact that the cause of the so-called virus infected plants has not yet been traced to any single living factor, such as bacteria, fungi, protozoa, etc., it is of interest to know if they are caused by deficiency of nutrient supply from the soil. Manurial trials were therefore made in the study of Peach Yellows, Mosaic disease of Tobacco, etc. with the result that the cause of the disease could not be traced to soil deficiency. In the course of this paper interesting observations have been made on the chemical composition of healthy and diseased tissues, as also of soils, but the correlation is not highly significant.

The occurrence of starch in all the virus diseased plants and plant parts is perhaps the only unique feature. Woods first showed it to be present in tobacco suffering from mosaic and this was later confirmed by Hunger. In Peach Yellows a similar observation was made. Esmarch ascribes the accumulation of starch noticed in the Leaf-Roll disease of potato, to an extensive check in the translocation of the assimilates in the leaves. Neger could not trace any relationship between the degree of rolling and the quantity of starch tested. In 'Curly' top of beets starch is known to be increased in quantity as also in the case of Leaf-Roll diseased potato as shown independently by Campbell. According to True and Hawkins starch content of the affected spinach tops is slightly greater than the correspondingly healthy ones. Cranberry plants suffering from 'False Blossom' reveal a similar set of conditions. The present author has carried out a study of the starch content of healthy and spike diseased sandal and found that more starch is present in the diseased leaves. The work of Freiberg, Dunlap, and Mumford is discussed in this connection.

This accumulation of starch is perhaps due to defective translocation of the manufactured products and the various factors leading to this, are also considered.

The relation of other carbohydrates in these diseased and healthy plants has not received much attention from the various workers. What little has been done, has not clarified our knowledge on the various changes brought about by the disease.

Very little has been done on the chemical aspects except the nitrogen distribution.

The author has been engaged in the study of the organic acids and tannins in relation to the spike disease of sandal.

The tissue fluids of healthy and virus diseased plant parts have been little investigated. Harvey found a lower H-ion concentration in the mosaic infected tobacco plants. Lutman recorded a decrease in the osmotic concentration in the case of mosaic of potato. Significant studies have, however, been made in the case of sandal spike and 'curly' tops of sugar beets. In the former case, a physico-chemical study of the tissue fluids has been carried out by the author, in healthy sandal leaves and sandal leaves from plants which were in early and advanced stages of the disease. The several observations are discussed. In the latter, Mumford has made determinations of pH, electrical conductivity, freezing point, etc. in resistant and susceptible strains of beets.

11. Biochemical aspects of the virus diseases of plants.

Y. V. SREENIVASA RAO, Bangalore.

Profound metabolic changes are known to accompany the onset of virus diseases in plants. An accumulation of starch, increase of carbohydrates and reducing sugars is a common characteristic of most virus diseases. The nature of the reducing sugars is not yet known. Dunlap (1930) has reviewed the literature on the effect of the virus diseases in plants and finds that mosaic diseases are characterised by an increase of carbohydrates and decrease of total nitrogen in leaves while the 'yellows' showed the opposite variation.

In view of the fact that disease conditions not infrequently modify the demands of the organism to mineral constituents, a study of the ash constituents might reveal the nature of the abnormal conditions set up in the plant by disease-producing agent. L. H. True, O. F. Black, and I. James Kelly working on the spinach blight have shown that ash content is not quite different in normal and blighted spinach while others working on the same have found that spinach leaves contain an unusually high content of total ash belonging to the same class as tobacco, hop leaves, forage beet tops in containing from 16 to 20 per cent. of total ash. Generally calcium is lower and manganese higher in diseased

plants. The high content of manganese is correlated with the high oxidase activity of diseased tissues. Diseased leaves of sandal contain a fourth or fifth of calcium that is present in healthy leaves.

It has been noticed in the case of spike disease of sandal that the affected tissues have always a higher pH than normal ones due probably to the increase of organic acids with the onset of the disease.

One of the most important constituents that is affected in all these virus diseases is the nitrogen. Bonequet (in his study on the chemistry of the mosaic disease of sugar beets) was the first man to determine the nitrogenous constituents of healthy and diseased leaves. He found in the diseased leaves nitrite and ammonia nitrogen occurring in larger quantities than in healthy leaves. He came to the conclusion that nitrates due to reducing power of the internal bacterial flora, get reduced first to nitrites and the reduction sometimes proceeds even to a further extent, to the stage of ammonia. The same author found similar results in the case of the mosaic diseases of the potato.

Jodidi, Kellog, and True were the first, however, to make a systematic study of the distribution of nitrogen in the tissues of healthy and blighted spinach. These authors also observed similar results. Coon and Klotz in their investigation on the celery plant affected with parasitic fungi, found that a lowering of the total nitrogen had taken place similar to that occurring in the case of the diseases described before.

Narasimhamurti and Sreenivasaya (1929) have studied the distribution of nitrogen in the leaves of healthy and diseased sandal and have shown that there is generally an increase of total water soluble nitrogen and total nitrogen with the onset of the disease.

Total N. on moisture free material as percentages.

Healthy	..	2.35	2.90	1.91	1.77	2.34	2.15	1.91	1.73
Diseased	..	4.21	3.70	2.53	2.21	2.29	2.08	2.53	1.94

As can be seen from the table there are instances where the healthy plant contains more nitrogen than the diseased. Irrespective of total nitrogen the water soluble nitrogen is always greater in the spiked leaves than in healthy probably due to the proteolytic degradation with the onset of the disease.

The results are given in the following table:—

Water Sol. N. expressed on moisture free material as percentages.

Healthy	..	0.55	0.37	0.33
Diseased	..	0.77	0.39	0.37

A detailed investigation of the distribution of the hexone bases in healthy and spiked sandal leaves was carried out with a view to ascertain the nature of the metabolic disturbances which manifest themselves with the onset of the disease. The results are given in the following table:—

Total Basic Nitrogen 100.

		Healthy.	Spiked.
Arginine	..	66.48	25.91
Histidine	..	3.60	43.84
Cystine	..	16.37	6.34
Lysine	..	13.42	23.69

The association of an abnormal amount of histidine in the diseased condition coupled with the fact that one of the first symptoms of spike is the dying of root ends, leads to the significant suspicion that histidine is getting decarboxylated with the production of histamine, a compound which is known to inhibit the growth of roots.

Arginine is closely associated with the reproductive metabolism of plants and animals. Without arginine, the seedling is adversely affected and the low arginine value obtained in the diseased condition perhaps to a certain degree explains the gradual suppression of reproductive activity with the development of the disease.

12. Physiological studies—Enzymes.

B. N. SASTRI, Bangalore.

Significant changes in the activities of enzymes are observed in plants after the onset of disease. Indeed, at one time it was believed that the causal agency of the virus diseases is of the nature of an enzyme, a theory, which has recently been supported by the work of Vincent (1932) on tobacco mosaic. Chlorosis is accompanied by profound disturbance in the oxidase activity. Low catalase and high oxidase activities appear to characterise the mosaics. The tissues of sugar beets affected by curly top and curly leaf exhibit high oxidase activity. The same is the case with potato affected by mosaic. Increase in diastatic activity has also been observed in diseased tissues.

A study of the enzyme make up of the sandal tissues in the healthy and spiked conditions show that both the diastatic (measured by sugar production) and oxidase activities are enhanced in the diseased condition. This is also true of *Dodonea viscosa* affected by spike. In the case of the starch splitting enzyme it has been observed, that the healthy tissue enzyme is a better liquifier than that obtained from the spiked tissue. The significance of some of these results in relation to starch accumulation, organic acid production and respiration has been indicated.

V. CONTROL METHODS.

13. Control measures in the study of the virus diseases of plants.

A. V. VARADARAJA IYENGAR, Bangalore.

1. *The elimination of infection centres.*—In considering preventive measures in the case of plant diseases, two factors are of importance, viz. the removal of the carrier of the infection and the infection centre where the multiplication of the pest occurs and from which the malady spreads. In the latter case it is always the infected host. Hence the basic control method must aim at the destruction of the infected plants or plant parts.

Collection and destruction of diseased material in any form, present a difficult problem in so far as a thorough and efficacious method is uneconomical. In the case of Peach Yellows, the diseased trees are a constant menace to the other healthy trees in a locality and hence prompt removal of these is practised. A similar procedure is adopted in the case of Little Peach another disease of peach caused by a virus. In potato affected with Leaf-Roll disease, the problem is inseparably connected with the mosaic and other virus diseases. The plots where the tuber is to be grown, are carefully 'rogued' and sprayed at intervals for the control of insects. In the case of seed potato, plots where Leaf-Roll disease is absent, are to be selected.

In sandal spike although no carrier of the disease has been established till now, in view of the infectious nature of the disease, the removal of the affected plants cannot be over-emphasised. The destruction is effected through plant poisons, containing arsenic as the chief ingredient.

Destruction of the infected host is the only method apart from the use of resistant varieties and attention to insect vectors.

Masking of disease symptoms is well established in the case of potato-mosaic and sandal spike and the recognition of the disease may not therefore be simple.

In a few other cases, the disease is considered to be connected with the occurrence of wild hosts of the same species and hosts of other species acting as intermediary hosts, with or without exhibiting the disease symptoms.

The several aspects of the above problem are discussed in detail.

2. *Elimination of the carrier of infection.*—The methods adopted in this connection are considered.

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RULES.

INDIAN SCIENCE CONGRESS.

1. The name of the Association shall be the Indian Science Congress, and its object shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including :

- (a) the holding and management of funds and property,
- (b) the acquisition of rights and privileges necessary or convenient for the object of the Association,
- (c) the management, development, improvement, disposal, and sale of all and any parts of the property of the Association.

2. There shall be an Executive Committee which shall carry on the administrative work of the Congress and submit such questions as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

3. The Executive Committee shall consist of the President, the Retiring President, the two General Secretaries, and the Treasurer (who shall be the Treasurer of the Asiatic Society of Bengal for the time being) of the Congress, the General Secretary of the Asiatic Society of Bengal for the time being, and five Permanent Members elected by the General Committee at its Annual Meeting during the Session of the Congress.

The Executive Committee shall co-opt as members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

4. The Executive Committee shall have full power to transact all business in case of emergency, notwithstanding any limitations herein-after laid down, and to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object ; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to rescission or alteration by the Executive Committee or by any meeting of the General Committee.

5. There shall be a General Committee which shall consist of all Permanent Members of the Congress and such Sessional Members as have held office in the Congress.

Officers of the Congress for the purpose of this Rule shall be : the Members of the Executive Committee and the Presidents and Recorders of Sections.

6. The General Committee shall meet at least once during each Session of the Congress, preferably in the middle of the Session.

7. There shall be a Council which shall consist of the Members of the Executive Committee, the Past Presidents of the Congress present in India, the Sectional Presidents for the ensuing Session, and, in addition, five Permanent Members elected by the General Committee at its Annual Meeting during the Session of the Congress.

8. The Executive Committee shall consult the Council on matters of general scientific import and policy.

9. There shall be a President who shall be nominated by the Executive Committee, and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

10. There shall be two General Secretaries who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

11. Each General Secretary shall hold office till the termination of the fifth Session of the Congress following the confirmation of his appointment, and shall be eligible for re-appointment.

12. In the event of a vacancy amongst the General Secretaries occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary for the period up to the termination of the next Session of the Congress.

13. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

14. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

15. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

16. For the purpose of scientific deliberation during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee.

17. There shall be Sectional Presidents and Sectional Recorders who shall be appointed by the Executive Committee.

18. There shall be Sectional Committees which shall consist of the following two officers :—

- (a) The President of the Section (Convener),
- (b) The Recorder of the Section,

and, in addition, of the following members :—

- (c) All Permanent Members of the Congress who have been President or Recorder of the Section concerned,
- (d) Two members elected by the General Committee at its Annual meeting during the Session of the Congress.

A Sectional Committee may co-opt two additional Permanent Members of the Congress of whom one at least shall be resident in the locality in which the ensuing Session of the Congress is to be held.

In the absence of the President of any Section from any of its meetings, the most senior member of the Sectional Committee present shall take the Chair.

The Sectional Committee shall meet on the opening day of each Session of the Congress and as often as may be necessary during the Session of the Congress.

Each Sectional Committee shall in its meetings during the Session of each Congress :—

- (a) nominate a Sectional President and a Sectional Recorder for next year's Session of the Congress for the consideration of the Executive Committee,
- (b) determine the detailed arrangements of the Sectional meetings,
- (c) select the papers to be read and discussed,
- (d) delete by a two-thirds' majority any abstract from final publication in the Proceedings,
- (e) determine the contents of the Sectional record in the Proceedings.

19. (a) Any paper submitted for reading at the Session of the Congress shall be forwarded to the President of the Section concerned so as to reach him not later than a date to be fixed from time to time by the Executive Committee.

(b) Any paper submitted for reading at the Session of the Congress shall be accompanied by an abstract in triplicate.

(c) Any paper submitted for reading at the Session of the Congress shall be refereed by the Sectional President or by some person or persons appointed by him. Decisions with regard to acceptance or refusal of any paper for submission to the Sectional Committee shall be final and all reports confidential.

(d) No published paper shall be accepted.

20. The Congress shall consist of four classes of members :—

(a) *Permanent Members.*

Annual subscription Rs. 10/-.

The subscription shall become due on the 1st of February of each year and shall only be effective as a payment for Permanent Membership subscription if paid before the 15th of July of the year.

(b) *Sessional Members.*

Subscription Rs. 10/- per session.

(c) *Associate Members.*

Subscription Rs. 5/- per session.

(d) *Student Members.*

Subscription Rs. 2/- per session.

(A Student Member must be duly certified by the head of his institution to be a *bona fide* student.)

Permanent and Sessional Members shall have the right of contributing papers for reading at the Session of the Congress and to receive free of charge all publications relating to the Session for which they are members.

Associate and Student Members shall have the right of contributing papers for reading at the Session of the Congress provided they have been communicated by a Permanent Member.

21. Any Permanent Member may compound for the payment of all future annual subscriptions by the payment in a single sum of Rs. 150/-.

22. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Indian Science Congress :—

- (i) Proposals for additions to and alterations in the existing Rules of the Indian Science Congress may be placed at any time before the General Committee by the Executive Committee.
- (ii) (a) Proposals for additions to and alterations in the existing Rules by any Permanent Member of the Congress shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.
- (b) One of the General Secretaries shall circulate such proposals to all Permanent Members of the Congress at least one full month before the meeting of the General Committee.
- (c) Any amendments to the proposals shall be sent by any Permanent Member of the Congress to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.
- (d) The proposals together with any amendments, shall be brought up before the meeting of the General Committee at its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two-thirds' majority of the constituent Members present at the meeting.

(Adopted the 5th January, 1931.)

